

Micro-Atmospheres: Investigating Portable and Wearable
Solutions to Support Individual Thermal Comfort in
Open-Plan Offices

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Statement of Originality

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Details of collaboration and publications:

All research and contributions in this thesis and the associated publications are my own work. The research was supported by Dr Nick Bryan-Kinns within the scope of his role as my primary supervisor and by Dr Karen Shoop within the scope of her role as my secondary supervisor, and both are acknowledged as authors in related publications. Previous publications related to this thesis are described in Section 1.5.

Abstract

This thesis aims to challenge existing approaches to the study of thermal comfort by addressing it through the design of wearable and portable personal thermal devices. Engineering-led approaches to thermal comfort have developed norms and standards to provide comfortable environments. Nevertheless, thermal comfort is very often difficult to achieve, especially in shared environments, as the perception of what is comfortable is highly subjective and varies among occupants. Accordingly, the focus of enquiry is shifting towards personal solutions, however, this has not included yet a critical investigation of their use in context, of design aspects and affordances.

To address these open questions, a Research through Design approach was implemented to reframe the problem space using design artefacts as vehicles for the enquiry. Mixed methods from two domains, namely, thermal comfort research and HCI, were employed to study in the field how thermal comfort is achieved and perceived, and to derive implications for the design of future personal wearable and portable thermal solutions. The investigation was based on a human-centred design process, which included an initial analysis phase and a design phase with three iterations of low-fidelity and mid-fidelity prototype development and testing.

Due to its transdisciplinary nature, this work contributes to the fields of thermal comfort research, HCI and wearable design. Contributions to thermal comfort research are made through findings in respect to the complexity of the achievement of thermal comfort, which include exploration, adaptation and the transcendence of different comfort layers. Implications on the design of personal thermal devices derived from the investigation contribute to the body of knowledge in wearable design and HCI and include utility-related aspects but also a need for openness in design and for emotional design to support exploration, adaptation, and the social role of the artefact at the crossroads between functional element and fashion item.

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List of Abbreviations

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CS	Peter Landin Building, Computer Science
Eng	Electronic Engineering Building
HCI	Human Computer Interaction
HVAC	Heating, Ventilation, and Air Conditioning
IEQ	Indoor Environmental Quality
MEMS	Micro-Electro-Mechanical Systems
ODI	Open Data Institute
PEC	Personal Environmental Conditioning
POE	Post Occupancy Evaluation
PV	Personal Ventilation
RtD	Research through Design
TAC	Task Ambient Conditioning

Chapter 1

Introduction

1.1 Motivation

Many human everyday actions and decisions centre on the achievement and provision of thermal comfort (Humphreys 1995; Shove 2003): whether it is adjusting the thermostat or opening windows to create a comfortable indoor environment or choosing an outfit for comfort throughout the day to match climatic conditions. Staying warm or cool is an essential and natural part of daily life (Heschong 1979). Thermal comfort is a requisite, as it affects the performance and well-being of human beings. Poor design of environments and poor indoor environmental climates can lead to health issues, reduce productivity and satisfaction (Leaman & Bordass 2005; Vink, Overbeeke, et al. 2005). Guaranteeing comfortable indoor conditions is consequently one of the main objectives in the design and development of human dwellings. Over the centuries, humankind has developed intricate and extensive heating and cooling strategies to achieve this, either by architectural, behavioural, or technological means, and research has been conducted to find the most optimal temperatures for human comfort (Heschong 1979; Shove 2003).

Although standards have been developed, which describe zones of comfort for indoor environments and which are used nowadays to regulate indoor environments across the globe, the perception of comfort and what is comfortable remains highly subjective (ASHRAE 2013; Vink, Looze, et al. 2005). The perceived experience of comfort is influenced by a multitude of factors, which include our expectations and past experiences, our mental state and how and what we feel at a certain point in time (de Dear et al. 1998). Problems with the achievement of individual comfort arise especially in environments like modern open-plan offices, in which the level of control available to the individual and consequently the possibilities to adjust local environmental conditions according to one's own needs are limited (Chappells & Shove 2005). Although the positive effects of perceived control on perceived comfort and productivity have been established, personal environmental control systems (PEC) are not very widespread (de Dear et al. 2013).

Traditionally, human beings have taken advantage of wearable or portable aids to overcome and bridge moments of discomfort on an individual scale, whether by putting on or taking off a piece of clothing or using, for example hot or cold-water bottles or ice packs as personal sources of heating or cooling. Research into wearable and portable solutions for personal thermal comfort can address individual needs by shifting focus from global to

individual and static to mobile provision of comfort in shared spaces. Existing research in the field of wearable technology for heating and cooling has predominantly addressed applications for extreme conditions or special use cases and focussed accordingly on the effectiveness and efficiency of the solutions (Wang et al. 2010; Yazdi & Sheikhzadeh 2014), although in recent years research into personal environmental control systems has been extended to include wearable devices for thermal comfort (Zhao et al. 2013; Song et al. 2015; Itani et al. 2017; Udayraj et al. 2018).

At the same time, advances in technology and a growing interest in wearable applications sees an increasing number of commercial solutions and aids for personal use introduced in consumer markets (Walker 2013; Hanuska et al. 2017). The availability of respective technology as well as the increasing adoption of wearable and portable personal devices in consequence allow to reframe and revisit the age-old question of thermal comfort and shift the focus from its provision on a global to a local scale addressing the needs of the individual. To transcend current limitations of research methodologies employed in the field, this thesis proposes to study the perception and achievement of thermal comfort through the design of personal thermal devices by taking a close look at how users interact with these devices in context and how different aspects of design of these devices responds to and addresses user needs. In turn, looking at aspects of thermal comfort in the design of wearables can help overcome the bias in current wearable research and development in form of body-worn monitoring, as well as information and communication technology by extending the field towards more functional applications addressing basic human needs (Hanuska et al. 2017). In consequence, studying thermal comfort through design can lead to the formulation of design requirements for personal thermal devices.

1.2 Aim

This thesis aims to challenge existing approaches to studying thermal comfort by addressing the question of individual thermal comfort through the design of wearable and portable personal thermal devices. Research through design allows to reframe the problem towards desirable states of reality by producing prototypes, which serve as vehicles to initiate discussion and challenge existing ideas, and whose evaluation allows to discover effects and bring general theories to a specific problem space, group and context (Zimmerman et al. 2007).

The main research questions based on the aspects addressed in the motivational statement are:

- How do occupants achieve thermal comfort through adaptation and use of personal thermal devices in context?

- How does their use of personal thermal devices impact perceived individual comfort, satisfaction, and perceived control in open-plan office environments?
- How do wearable or portable personal devices for thermal comfort have to be designed to support perceived thermal comfort, control and use in context?

1.3 Thesis Structure

This thesis gives an overview of the research undertaken to answer the questions stated previously and of the possibilities, chances and challenges involved.

Chapter 2 contextualises this work in the relevant literature and establishes the background and related research, which includes an introduction to and discussion of thermal comfort, an overview of the most important related developments and concepts involved in thermal comfort research, human computer interaction (HCI) and wearables, and a brief overview of different existing wearable or portable thermal devices and technologies. Chapter 2 concludes with an identification of the research area.

Chapter 3 gives an account of the approach, the research methodology as well as the methods employed to study the achievement and experience of thermal comfort through the design and use of personal wearable or portable thermal devices. The field study-based investigation was supported by mixed methods from both HCI and thermal comfort research.

Chapter 4 presents the findings of a pilot study conducted to uncover the parameters affecting individual comfort in the context and setting that would frame the research.

Chapter 5 presents the findings of two user studies, which evaluated the use and usability of off-the-shelf, portable or wearable personal heating and cooling devices in the field. The findings of the studies resulted in the formulation of design requirements and recommendations for areas of further investigation for wearable personal heating and cooling, which informed the user studies of chapter 6, 7 and 8.

Chapter 6 describes the layout and findings of a low-fidelity user study, which was conducted to test first prototypes for personal portable or wearable heating or cooling developed based on the findings of the user study described in chapter 5. The low-fidelity study was scenario-based, which assisted in further refining the focus of the development of a device for individual comfort as well as areas of further investigation.

Chapter 7 presents the closer investigation of the role of affordances and appropriation of personal devices on the achievement of thermal comfort through the design and development of a portable and a wearable personal heating prototype and the study of their use in the field. The findings of the user study contribute to an understanding of the different levels involved in the achievement of thermal comfort as well as the necessity of an open design and regard for fashion to support needs on a higher level.

Chapter 8 presents the findings of a user study investigating the implications of manual and partly automated control modes through the development of a personal wearable cooling device. It reports on the acceptance of a partly autonomous system and explores the trade-offs considered by participants in trading control for convenience.

Chapter 9 critically discusses the main findings in respect to thermal comfort and the design of wearable personal thermal devices across the studies undertaken in the scope of this project and presented in chapter 4 to 8 in relation to previous research undertaken in the field. It furthermore discusses and evaluates the methodological approach, its benefits and shortcomings.

Chapter 10 wraps up this thesis by stating the key findings and contributions of this research and laying out potential areas for further research.

1.4 Contributions

This thesis is relevant to the field of thermal comfort research, in particular to further studies in the field of PEC systems, as well as the field of wearable design and HCI. The thesis contributes to the field of thermal comfort research by showing how a transdisciplinary research through design (RtD) approach can reframe the problem space and provide new insights and directions for research into thermal comfort, wearable and portable PEC systems and their design, as it allows to study perceived individual thermal comfort more holistically and in context with design artefacts acting as catalysts to the enquiry. The application of the approach in transdisciplinary form using mixed methods from both fields and consisting of an analysis phase, which included a pilot survey (chapter 4) and an initial user study (chapter 5), and a design phase, which included a low-fidelity study (chapter 6) and two user studies in the field (chapters 7 and 8), showed how such a RtD approach could be framed, grounded and given the necessary relevance and thus contributes to the body of knowledge in HCI research.

The study of affordances in personal heating devices (chapter 7) contributed insights into the behavioural adaption processes taking place in the achievement of thermal comfort. It was found that adaptation and appropriation of personal thermal devices is accompanied by

active exploration of the affordances of the device in situ, which can be considered a search for the optimal solution between eliminating the most pressing source of thermal discomfort and thus improving perceived thermal comfort, ergonomic fit in the physical and habitual context and functional comfort in the activity space. Furthermore, it was found that the strive for thermal comfort transcends different layers, physical, functional and psychological, which underlay prototype use and adaptation observed on an individual scale.

The deployment of personal heating and cooling devices in the field showed that the availability of such a device increased the feeling of control over the local thermal environment and perceived thermal comfort (chapters 7 and 8). The impact of the mode of device control on the feeling of control over the local thermal environment and perceived thermal comfort proved to be in favour of manual over smart adaptive control for perceived thermal comfort (chapter 7). This was found to stand in contrast with a reported preference for adaptive control.

Furthermore, this thesis contributes to the design and development of personal wearable or portable systems for thermal comfort, as design implications affecting perceived usefulness and supporting active appropriation could be derived from the empirical evaluation of existing devices and design prototypes deployed in the studies described in chapters 5, 7 and 8. It was found that the usefulness of personal devices for thermal comfort is affected by their ability to provide heating or cooling when needed (availability), where needed (location), in the amount needed (control), and as long as needed (reliability) (chapter 5). Open design of personal thermal devices and their affordances further was found to support adaptation and appropriation and thus contribute to the achievement of personal thermal comfort in context (chapter 7).

The findings and contributions of this thesis are listed in extended form in chapters 10.1 and 10.2.

1.5 Associated Publications

Parts of the work detailed in this thesis have been presented at international conferences as follows:

Chapter 4: the results of the pilot study have been presented as a poster at 11th Biennial Conference on Environmental Psychology (BCEP) 2015.

Knecht, K., Bryan-Kinns, N., & Shoop, K., 2015. Assessing Comfort in Open-Plan Offices on Campus – Which Comfort Parameters Matter? Poster presented at 11th Biennial Conference on Environmental Psychology (BCEP); August 24th- 26th 2015; Groningen, Netherlands

Chapter 5: the results of the study on the usability of off-the-shelf heating and cooling devices have been published as a conference paper at British HCI 2016 – fusion.

Knecht, K., Bryan-Kinns, N. & Shoop, K., 2016. Usability and design of personal wearable and portable devices for thermal comfort in shared work environments. In Proceedings of the 30th International BCS Human Computer Interaction Conference, HCI 2016.

The research approach as well as early results of the evaluation of existing off-the-shelf personal heating devices were presented at the doctoral consortium at mobileHCI 2015.

Knecht, K., 2015. Micro-atmospheres: Exploring portable and wearable solutions to support individual thermal comfort. In MobileHCI 2015 - Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct.

Chapter 2

Background

This chapter establishes the context of this thesis, which is situated at the interface of thermal comfort research and the design of wearable and portable devices as fields of study.

Accordingly, this chapter presents the background of related research and relevant literature in both fields, which includes an introduction to and discussion of thermal comfort, an overview of the most important related developments and concepts involved in thermal comfort research, human computer interaction (HCI) and wearables, and an overview of existing research and development in wearable or portable thermal devices for thermal comfort.

2.1 A Critical Discussion of Thermal Comfort

Many human everyday actions and decisions centre on the achievement and provision of thermal comfort (Humphreys 1995; Shove 2003): whether it is adjusting the thermostat or opening the windows, or choosing an outfit for comfort throughout the day. Due to its complex nature, however, thermal comfort is a difficult state to achieve; it only enters conscious thought when it is lacking (Nicol et al. 2012). Although standards have been developed, such as EN 15251, ISO 7730:2005 and ASHRAE Standard 55-2013, which describe zones of comfort for indoor environments, the actual indoor climates occupants encounter often fall short in providing the right level of thermal comfort to all occupants (Cox 2010). The perception of thermal comfort and what is comfortable remains highly subjective. It has been widely suggested and accepted as a point for improvement in thermal comfort research that individual differences, such as age, gender, physiology and clothing levels, between people and their perception in respect to what constitute optimal thermal conditions cannot be fully met by a centralised system (Wang et al. 2018; Choi et al. 2012). At the same time comfort is a requisite, as it affects the performance and well-being of human beings. Poor design of indoor environments and indoor environmental climates can lead to health issues, reduce productivity and satisfaction (Leaman & Bordass 2005a; Wyon & Wargocki 2006). The shift from global, centralised to local, personalised provision of thermal comfort has therefore been the major paradigm shift in this area with personal environmental control (PEC) systems having been proclaimed the way forward to bridge the gap between the local microclimate and individual needs (de Dear et al. 2013).

The following subchapters give an overview of the state-of-art in the field of thermal comfort by first explaining the prevalent models of thermal comfort, how human beings

experience comfort, how they achieve it and the role perceived control plays in this before taking a closer look at PEC systems and existing gaps in research.

2.1.1 Thermal Comfort: Models and Critiques

Historically, personal thermal comfort has always been achieved out of the interplay of the provision of thermal comfort on different levels: balancing the microclimatic conditions of the local indoor or outdoor environments with measures at body level. The improvements in building systems and materials, as well as the rise of heating, cooling and air conditioning technology in the last century, has created an expectancy towards the provision of thermal comfort by the environment (Shove 2003). Due to its importance in respect to occupant satisfaction and due to the cost and energy involved in the running of HVAC systems, thermal comfort has been intensively studied over the past decades (de Dear et al. 2013).

In thermal comfort research, two models prevail: a steady-state heat balance model, which describes comfort as a function of the heat exchange between body and environment and was developed in the 1970s (Fanger 1970), and an adaptive model, which places the human occupants as active agents in a complex, dynamic and interactive person-environment system and which was introduced in the late 1990s (de Dear et al. 1997; de Dear et al. 1998). The adaptive model is based on findings from extensive field studies that comfort temperatures vary depending on the outdoor climate and season (Humphreys & Nicol 1998). Furthermore, it pays attention to the fact that people are not merely physiologically responding to the thermal sensations experienced in an environment at a certain point in time but that more complex mental processes and different behavioural, physiological and psychological adaptation processes are taking place with which people achieve comfort by interacting with and adjusting to their environment and its conditions (Humphreys & Nicol 1998; de Dear 2004). The understanding and notion of thermal comfort expressed in this model is reflected in the definition of thermal comfort as *“that condition of mind that expresses satisfaction with the thermal environment”* (ASHRAE Standard 55 in ASHRAE 2013, p.9.1).

Both models are applied in practice and form the basis of thermal comfort standards across the globe (ASHRAE 2013). The heat balance model is used in the prediction and design of comfortable indoor environments in air-conditioned buildings with uniform conditions, whereas the adaptive model is applied to describe comfortable environments in naturally ventilated buildings with non-uniform conditions (ASHRAE 2013). However, although the zones of comfort for indoor environments laid out in these standards should provide a thermally acceptable indoor climate for 80% of the occupants, the extent to which individual differences between people impact the actual experience of the built reality and let numbers deviate considerable from estimated or predicted conditions has long been underestimated in practice (ASHRAE 2013). Differences between participants in thermal sensation ratings have been found to be considerable varying by one to up to two units on a seven-point rating scale, which

equals a two to five degree difference of preferred temperature (Huizenga et al. 2006; Zhang et al. 2015; Wang et al. 2018). This means that dependent on building characteristics occupant satisfaction ratings can be well below the 80% mark in reality (Zhang et al. 2015).

The main criticism of how comfort is addressed in building design and how environmental quality and building performance are discussed is the reduction of comfort to a set of variables and that comfort is seen as a matter of technical control and engineering, which means that solutions focus and rely on HVAC systems rather than a human-centred design (Chappells & Shove 2005; Vischer 2008a). The reduction of the complexity of perceived comfort has furthermore been criticised to widen the gap between the actual experience of comfort of occupants as well as their achievement of comfort in the use of buildings and the notion of the designers and engineers, who are designing the environments based on calculations, measurements and comfort in degrees, which lack meaning for the actual experience of the individual (Chappells & Shove 2005; Cox 2010). Matters of dissatisfaction and discomfort occupants face include, for example, buildings being too hot in winter and too cold in summer, the lack of adaptive opportunities, or the lack of an understanding on part of the occupant of how to use these effectively (Nicol et al. 2012; Cox 2010). As the behaviour of occupants in respect to how climate control elements are used has a significant impact on the actual energy use of the building, the aim to optimise thermal performance and building energy use has led to an increased interest in how occupants interact with the building (de Dear et al. 2013).

Work in environmental psychology aimed to close the gap in adding a socio-cultural, holistic and human-centred approach to comfort and the built environment (de Dear et al. 2013). The environmental comfort model of workspace quality defines three levels of comfort: physical, functional, and psychological comfort (Vischer 2008b)(Figure 2.1). Physical comfort as the most basic level addresses basic human needs, which include, for example, safety, hygiene, and accessibility (Vischer 2008b). Functional comfort according to the model derives from but goes beyond the traditional comfort model defined by environmental standards, such as by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE 2013), which is based on measured occupant response to environmental conditions but links the occupants' perceived experience and environmental assessment to the requirements of the task or work they are performing (Vischer 2008b). Functional comfort is defined accordingly as the "*environmental support of user's performance of work-related tasks and activities*" (Vischer 2008b, p.100). Psychological comfort encompasses the experience of territoriality, control, and appropriation and include "*feelings of ownership, belonging, and control over the workspace*" (Vischer 2008b, p.100) and thus is connected to psychosocial aspects of the design and management of the space.

Both the transactional model as well as the environmental comfort model suggest that comfort is a perceptual experience resulting from the interplay between a human being and their

environment and cannot be described in subject-object terms and is affected by a multitude of parameters on different levels. As a consequence, the perception of comfort and how an environment and its qualities are perceived are complex to assess, which makes it a very difficult aspect to design for (de Dear et al. 1998; Vink et al. 2005).

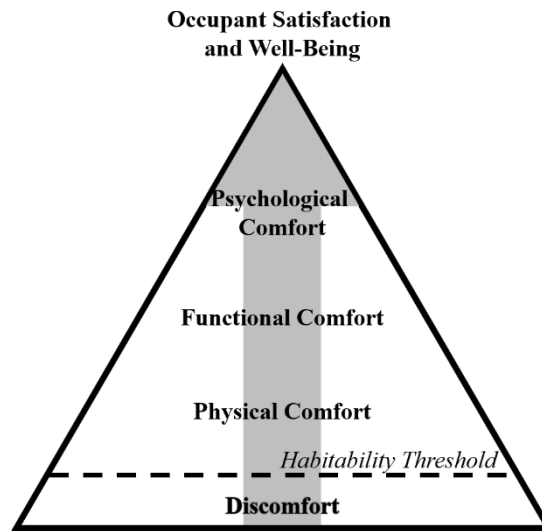


Figure 2.1: Workspace comfort model, after Vischer (2008b).

2.1.2 Perceptions and Sensations: How Thermal Comfort is Experienced

Thermal and acoustic comfort are generally deemed most influential on the overall perception of indoor environmental quality (IEQ)¹ (Frontczak & Wargocki 2011). Temperature in combination with the freshness of air and air movement, plays the key role in the occupants' assessment of and satisfaction with an indoor climate (de Dear et al. 2013). According to (Brager & de Dear 1998), the satisfaction of a person with their indoor environment is based on the matching of the thermal conditions as they are to their expectations of what they should be. Parsons (2003) defines expectancy in this regard as "*a confidently predicted future state*" based upon "*the personal model of the world of an individual involving his or her psychological characteristics, experiences and culture*" (Parsons 2003, p.69). In consequence, comfort is a dynamic process, which evolves out of the lived and embodied experience of the human being in relation to their surroundings, overlaid by expectations, emotions and past experiences.

Satisfaction with the thermal environment is reached, when the body is in a state of equilibrium (Nicol et al. 2012). However, it has been discussed that the response of people to their physical environment is only reported as either neutral or negative, which means that a supportive thermal environment does not get noticed (Vischer 2008a). Positive satisfaction can

¹ Aspects commonly regarded in respect to indoor environmental quality (IEQ) include environmental as well as personal and physiological parameters: temperature, humidity, airflow, noise, smell, lighting and other visual aspects, contact to the exterior, layout, cleanliness, facilities, as well as clothing and activity levels, constitution and health [Hellwig2009]. These form the basis of green building certification, such as Leadership in Energy and Environmental Design (LEED) (U.S. Green Building Council 2018) or the Building Research Establishment Environmental Assessment Method (BREAM).

be expressed only in varying conditions, when the perception of the thermal bodily condition moves from uncomfortable to the equilibrium, which has been described as ‘thermal delight’ (Heschong 1979; Nicol et al. 2012).

Individual differences in the perception of thermal comfort have been linked to physiological factors, age and health related aspects, such as metabolic rate and fitness, or differences in thermal adaptation and clothing levels, the latter especially between genders (Humphreys & Nicol 1998; ASHRAE 2013; Wang et al. 2018). Differences in temperature perception have also been found to exist between different parts of the body with varying impact on overall perceived comfort. Studies on the effect of thermal sensation of different body parts on perceived comfort have found that the thermal perception of hands and feet in cool environments and of the head and hands in warm conditions are decisive and affecting the perception of overall comfort or discomfort of occupants (Arens et al. 2006a; Arens et al. 2006b).

2.1.3 Adaptation: How Thermal Comfort is Achieved

At the centre of human thermal adaptation processes stands the need to regulate the human body temperature in order to keep the essential core temperature constant, prevent excessive heat loss in cold conditions and overheating in hot conditions (Nicol et al. 2012). The experience of thermal discomfort is a signal of the body that the environment might pose a health threat (Nicol et al. 2012). Although buildings rarely reach temperature levels posing a serious direct threat to life, thermally uncomfortable environments can increase heat and cold related illnesses and affect occupant health indirectly (Nicol et al. 2012). Any deviation away from an individual optimum level of thermal comfort leads to affective, cognitive and behavioural responses, i.e. processes of adaptation, which have been defined as follows: physiological, i.e. by acclimatisation, behavioural, i.e. by changing aspects of the environment, for example, by opening windows, or of personal aspects, such as clothing or activity, and psychological, i.e. by habituation, e.g. through adjusting expectations and attitudes (de Dear et al. 1998; de Dear 2004; de Dear et al. 2013; Heerwagen & Diamond 1992).

Physiological adaptation in form of acclimatisation is an unconscious process. The basic model of human physiological thermoregulation states that if the body becomes too hot, it loses heat by vasodilation and sweating, and if it becomes too cold, it preserves heat by vasoconstriction and generates it by shivering (Parsons 2003). Glabrous skin, which is located at specific areas of the body including the palms, the soles of the feet, parts of the face and the ears, supports heat transfer through vasodilation (Grahn et al. 2009). Under repeated thermal stress adaptation takes place over days or weeks, for example, by increasing the body’s capability to sweat production under repeated heat stress (de Dear et al. 1997; Parsons 2003). Psychological adaptation takes place in form of coping, for example, by managing one’s thoughts, emotions, expectations or attitudes towards a situation that is perceived as stressful

(Heerwagen & Diamond 1992). However, the success of psychological coping strategies is considerably less than of other forms of adaptation, as their focus is on ignoring rather than addressing the actual problem and do not provide actual relief from discomforts (Heerwagen & Diamond 1992).

Among the different forms of adaptation, behavioural adjustments have been described as the “*most powerful form of human thermoregulation*” (Parsons 2003, p.35) and an opportunity for occupants to take active control to ensure their personal comfort (de Dear et al. 1997). Adaptive actions undertaken by occupants in order to restore comfort include the regulation of the rate of body heat loss, e.g. by adding or removing clothing and changes of posture, the regulation of the thermal environment, e.g. by turning the heating or a fan on, selecting a different thermal environment, e.g. by moving to a different place short or long term (Humphreys & Nicol 1998). However, the environment and the physical and social context place constraints on behavioural adaptation, e.g. due to climate, building design, social organisation, task or occupation, regulations or economic reasons, and determines how much control and adaptive opportunities are available (de Dear et al. 1997). Social adaptive constraints placed on the individual can include matters of company culture and the obligation to wear specific clothing, as well as fashion and gender-related norms (Humphreys & Nicol 1998; Chappells & Shove 2005).

2.1.4 The Importance of Control

Work on the sick building syndrome in the 1980s discovered that people's perception of how much control they have over their environment directly affects their comfort and satisfaction with the environment (Leaman & Bordass 2005b). It has been found that the amount of perceived individual control over related environmental parameters is more important than the actual environmental state and impacts perceived comfort, satisfaction, health and productivity (Paciuk 1990; Leaman & Bordass 2005a; Leaman & Bordass 2005b; Leaman & Bordass 2005c). Accordingly, it has been stated that “*discomfort is caused by excessive constraints being placed on these processes of choice and adjustment, rather than by the temperature itself, except in extreme conditions*” (Humphreys 1995, p.5). A study by Luo et al (2016) uncovered that the effect of perceived control on perceived thermal comfort is to a large extent psychological and that thermal comfort was also voted higher when perceived control did not correspond to actual control over the local thermal environment. Further direct relationships also persist between perceived control, perceived health, perceived comfort and perceived productivity², i.e. the more control occupants perceive to have, the better they rate their health,

² In general, productivity can be defined as the “ability of people to enhance their work output through increases in the quantity and/or quality of the product or service they deliver” (Leaman & Bordass 2005a, p.3). However, productivity cannot always be measured objectively. Especially in office environments with varying tasks this is deemed close on impossible or involves a significant reduction of complexity of the task, e.g. by just counting key strokes of all office workers without regarding the circumstances. This

comfort and productivity (Leaman & Bordass 2005b). A direct relationship has been found to exist between the perception of comfort and the perception of productivity, i.e. if the perceived comfort of occupants is low, they do also rate their productivity to be lower.

It can furthermore be stated that the more control opportunities are perceived to be available to occupants the more tolerant they are of the environmental conditions and the less inconvenienced they are by them (Brager & de Dear 1998). As a result of extensive field studies, de Dear, Brager and Cooper (1997) also found that occupants of naturally ventilated buildings achieve thermal comfort over a wider range of temperatures, which they attributed to a difference in thermal comfort expectations and a higher level of perceived control.

However, several factors impact perceived control and in turn perceived comfort. Perceived comfort varies among occupants in the same room depending on how accessible controls are from their workplace, for example, satisfaction with the indoor climate is higher if a person is seated next to a window (Raja et al. 2001). Perceived control and comfort have also been shown to decrease with the increase of the size of rooms and workgroups, as any changes to the indoor climate have to be made in consideration of the comfort of colleagues (Leaman & Bordass 2005c). In addition, the more people share a space, the more difficult it will be to accommodate everybody's individual preferences and the less likely it will be to find a state everybody is satisfied with (Leaman & Bordass 2005c). Also, practical aspects play a role. Increasing room sizes usually lead to an increase of the size of zones of control, e.g. for lighting, heating or cooling the space, as well as the increase of remote effects, such as draughts, glare or noise (Leaman & Bordass 2005c). In a field study on the use of controls in naturally ventilated buildings, it was shown that occupants operate a combination of different control options to improve the thermal indoor environment (Raja et al. 2001). Next to available building related control, such as windows and curtains/blinds, fans have been found to play an important role to alleviate heat stress (Raja et al. 2001). Although the availability of control over environmental conditions and adaptive opportunities are of importance in respect to perceived comfort and IEQ satisfaction levels, a study on adaptive behaviour in a UK office environment found that adjustments on a personal, local level, such as clothing, are the preferred adaptive choice over adjustments on a more global scale, such as heating, fans, or windows (Liu et al. 2014).

Although perceived control has been found to have a positive impact on perceived comfort and satisfaction with the indoor environment, exercising or having to exercise control might have the opposite and thus a slightly negative effect (Paciuk 1990). It has been argued that having to take too many decisions, to exercise control too often or this to entail a complex process might have a negative impact on the occupant's experience and requires a higher cognitive load (Heerwagen & Diamond 1992; Boerstra et al. 2015). Research on the impact of control on productivity and thermal comfort found that objective and perceived performance of

problem has been solved in comfort research by using scales of perceived productivity and the evaluation of self-assessed, subjective levels of productivity.

participants was higher when the system was automatically controlled in comparison to manually controlled (Boerstra et al. 2015) and that it did not impact perceived thermal comfort (Veselý et al. 2017), although participants in both cases reported a preference for the manual control setting. The discrepancy between the preference of manual control over automated control has therefore been at the centre of a user study on wearable cooling, which is presented in chapter 8.

2.1.5 Supporting Individual Thermal Comfort: Personal Environmental Control Systems

As an awareness for the benefits of personal thermal control for indoor environmental satisfaction, health, and productivity has been increasing, so has the question of how this could be achieved and addressed (De Dear & Brager 2002; de Dear et al. 2013). Personal environmental control (PEC) or task ambient conditioning (TAC) systems have been described as solutions, which can help to address individual differences and comfort needs in the built environment (ASHRAE 2013). Unlike centrally controlled or zone controlled HVAC systems³, PEC or TAC systems possess outlets, modules or vents at each workplace, so that occupants can adjust temperature and/or air flow individually within their personal space (Veselý & Zeiler 2014). Heating elements have also been added to office furniture, such as chairs and desks, as well as the floor (Zhang et al. 2008; Veselý et al. 2017). Studies have shown that TAC and PEC systems can increase comfort and occupant satisfaction across a wider range of temperatures compared to centrally controlled units (Bauman et al. 1998; Zhang et al. 2008). Furthermore, it has been noted that these systems might help reduce overall energy consumption, as energy for heating or cooling is only applied to a localised area and when needed (Veselý & Zeiler 2014). In a study by Zhang et al. (2008) PEC systems were found to help reduce energy consumption by up to 40%. However, research in personal ventilation (PV) systems using simulation techniques has shown that this is may be dependent on several factors, such as the ventilation strategy employed, e.g. mixing ventilation vs. PV only, frequency of use, i.e. continuous vs. on demand, and the context, i.e. cold vs. hot and humid climates (Schiavon & Melikov 2009; Schiavon et al. 2010).

Apart from early studies by Bauman et al. (1998) and more recently by Shahzad et al (2017) respective studies on PEC and PV were conducted in climate chambers, i.e. in controlled environments, or used simulations, which did not possess the complexity of real life settings. Field research of PEC and TAC systems had been identified accordingly as an area that has not

³ In general, building environmental control systems can be organised in either a centralised or decentralised way. Centrally controlled HVAC systems leave the occupants with no control over their environment. Adjustments to the temperature have to be made by building managers or respective staff. Zone controlled systems can be controlled via a thermostat or directly at the outlets, such as radiators.

been extensively addressed yet and was in need of further research (de Dear et al. 2013). In response to the challenge recent research has opened up the field and is also looking at wearable solutions to increase personal control of the thermal environment, which will be discussed in subchapter 2.2.4.

2.2 Personal Devices: Wearable Technology for Individual Use

With the advancement of networking and sensor technology, an increasing number of wearable systems is reaching consumer markets with further expansion in the field of smart clothing expected (Walker 2013). However, research and development of wearable technology is reaching as far back as the 1960s, when early prototypes were built and studied (Thorp 1998). Research and development into smart wearable systems is situated at the intersection of design research, human physiology and psychology, as well as fashion and textile theory and technology (Uotila et al. 2006; Suh et al. 2010). Research in the field of HCI, usability and user experience research can help to develop more usable and desirable wearable devices, whereas background knowledge in fashion and clothing can help to support the shift from interacting with technology towards mediating human-environment interaction and communication through technology (Mann 2001; Uotila et al. 2006; Flanagan 2015).

The following subsections will introduce wearable technology and how common concepts from HCI, which include the theory of affordances and design for usability, usefulness and user experience, can contribute towards their development. A special focus will address the design for wearable systems and discuss the requirements of body-worn, ubiquitous devices in respect to wearability, unobtrusiveness, self-image and new forms of interaction. Furthermore, an overview of the current state of art in the field of wearable thermal devices will be given and areas for further research in the field discussed.

2.2.1 Introduction: What is ‘Wearable’?

Although “wearables” is commonly used as an umbrella term to denote a whole range of devices, technologies and applications that can be carried, attached to and worn on the body in this expanding field, two main technological approaches to wearables can be distinguished: a textile-based and garment-integrated approach, also called smart clothing, and an electronic-based and body-mounted approach, also called wearable computing (Dunne et al. 2005; Mattila 2006; Toney et al. 2006). Within the smart clothing category a range of labels have been given to the developments in the textile-based field, which range from smart or intelligent textiles to e-textiles featuring conductive yarns and yarn integrated electronic components allowing for so called soft circuits (Wilson 2005; Stoppa & Chiolerio 2016). Garment integration can furthermore be achieved in form of added electronic components and circuits to clothing or

other textile-based carriers (Wilson 2005). Electronic-based wearable technology mainly comes in form of wearable computing devices, such as wrist-worn or head-worn technology-enhanced accessories, which includes smart watches and wrist-bands, glasses, and other forms of jewellery (Barfield et al. 2001). The smartness of wearable technology is distinguished in three categories: passive smart, active smart and ultra-smart (Stoppa & Chiolerio 2014; Stoppa & Chiolerio 2016). A passive smart device is able to sense its environment, an active smart device can in addition respond to the environmental input it received and very smart devices can learn and adapt their behaviour over time (Stoppa & Chiolerio 2016).

Whereas commercial applications in the smart clothing sector at the time of writing are remaining relatively scarce, body-mounted wearable computing has seen a constant rise in the number of available consumer products, market volume and market share (Hanuska et al. 2017). With a combined market share of 90% in the consumer wearables market in 2015 (IDC Research 2016), wrist-worn activity and health monitoring devices dominated the field, such as the Fitbit (Fitbit Inc. 2017), and smart watches, such as the Apple Watch (Apple Inc. 2017), which combine health and fitness monitoring with smartphone/communication facilities. Fitness and wellness, as well as lifestyle and entertainment are two of five important categories of wearable technology, which most current wearable consumer products on the market fall into (Hanuska et al. 2017). Upcoming applications for smart clothing are mainly seen in the areas of healthcare and fitness, for example, for performance monitoring, in the industrial context, for example, for tracking and detection of unfavourable environmental conditions, such as industrial gases, and in the military, for example, in clothing that senses and transmits physiological and environmental states and controls personal temperature (Walker 2013; Hanuska et al. 2017).

Key to the development of wearable technologies have been the evolution of networking technologies allowing for faster and more reliable mobile and wireless communication as well as the increasing efficiency and decreasing size of power supplies (Starner 2015), as well as of sensor technologies, such as micro-electro-mechanical systems (MEMS) and low energy Bluetooth for operation and sensor support (Walker 2013). All of these factors have enabled wearable applications, reduced the size of wearable systems and thus have been increasing their adoption.

2.2.2 Designing Useful Systems: Affordances, Usability and Acceptance in Design

Affordances describe the action possibilities provided to an actor by the environment within it or in other terms its adaptive opportunities (Gibson 1979). In the original sense, affordances help to understand how animals or, in this respect, human beings perceive their environment (Kaptelinin 2016). The concept of affordances was picked up by Norman (1998), who brought it

to design. Norman distinguishes between the “perceived or actual properties of the thing” (Norman 1998), which means between the actual or real affordances of an artefact as a measurable entity and perceived affordances, which are relational components that come into existence out of the interplay between a user, their experience, knowledge, or culture, and an object or environment (Norman 1999; McGrenere & Ho 2000; Kaptelinin 2016). This differs in respect to Gibson’s original definition of an affordance existing independently of whether an actor perceives it or not in as such that Norman defines affordance as an action possibility that exists but also has to be perceived by an actor (McGrenere & Ho 2000).

In interaction design, affordances refer to the possible uses or possibilities of action of a product or device and addresses the question of how to make these visible to the user so a design artefact is intuitive to use (Kaptelinin 2016; Norman 1998). Designing affordances in devices and applications means considering the relationship of the user with the artefact, the context of use, object form and the range of possible, required or desired actions (Norman 1999; Dourish 2001). Perceived and actual affordances have also been coined as ‘cognitive’ and ‘physical’ affordances (Hartson 2003) and as such have been closely linked to the usability of devices or applications in HCI (Djajadiningrat et al. 2002; Norman 1998; Hartson 2003). A design framework, which distinguishes between the design of affordances of objects or systems, their usefulness, and the design of the information that leads to their perception, their usability has been proposed by McGrenere and Ho (2000). Usefulness is defined as the affordances provided by a system, the functionalities, and whether they allow a user to reach their goals, whereas usability is defined by the clarity, with which information is designed to make the affordances visible. In usability literature, however, usability is rather seen as a subset of the usefulness of a system in achieving a specific purpose (Nielsen 1994). In this respect, the affordances or functionalities provided by a system are declared as ‘utilities’ (Nielsen 1994; Bevan 1995).

Usability has been defined as the “*extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*” (ISO 2018). Effectiveness regards the extent to which a system allows users to reach their goals, whereas efficiency relates to the effort that has to be put in to do so (Quesenbery 2014; ISO 2018). Satisfaction encompasses the extent to which a user’s needs and expectations are met (ISO 2018). The additional aspects of learnability and error tolerance are very often added in relevant literature, in particular in respect to usability evaluation (Nielsen 1994; Quesenbery 2014). It is important to note that the current understanding of usability has moved from a product-centred view to seeing usability as the result of the interaction between the user and the object in its context of use (Bevan et al. 2015). It is therefore closely related to user experience, human perception and response towards a system, and human-centred design, i.e. the design of usable and user-friendly systems based on their use (Bevan 2009; Jokela et al. 2003).

User experience has been deemed to be the flipside to usability looking at human-system interaction from a user perspective, i.e. the user's perception and response to system use, and is targeted towards improving satisfaction with a product rather than its performance of use (Bevan 2009). User experience addresses hedonic qualities, such as stimulation, identification and evocation, and covers aesthetic, subjective, situated and dynamic aspects of experience in system use (McCarthy & Wright 2004; Hassenzahl & Tractinsky 2006). Both usability and user experience address the use of a system in its context of use, which not only respects the direct technical and physical context of user-system interaction but also the broader social and organisational environment in which the interaction takes place (Bevan 1995). Furthermore, both are subject to the dynamic evolvement of experience through the continuous reshaping of the user's perception of self under product use in the socio-environmental context (McCarthy & Wright 2004). It has therefore been proposed to address the lifecycle of user experience in the design and development of systems (Pohlmeyer et al. 2009). Openness to potential to create exciting design, allowing for appropriation in use or for creativity as well as appropriation of an experience (McCarthy & Wright 2004), which is closely related to the flexibility allowing for adaptation to varying tasks or environments as originally suggested as a criteria of usability (Shackel 2009). Usability has in particular been studied in respect to software systems and information and communication technology. In respect to the design of physical artefacts, user experience extends the design for affordances towards a so-called 'emotional design' (Norman 2004).

Perceived usefulness, i.e. the extent to which users believe a system or device will allow them to reach a specific goal and address a specific need, is alongside perceived ease of use, i.e. the extent to which users believe the use of a system to achieve their goal is free from effort, key to its acceptance and form the basis of the Technology Acceptance Model (TAM) (Davis 1989). In general, it has been argued that technology acceptance and purchase decisions are based on trade-off considerations, which have been summed up as a balance of utility, usability and likeability in a trade-off against cost (Shackel 2009). However, TAM has been extended to encompass aspects of subjective norms, such as social influences and self-image, and their influence on the perception of usefulness and on the intention of use (Venkatesh & Davis 2000). Furthermore, additional factors to influence perceived ease of use have been added, which include self-efficacy, perception of external control, anxiety, playfulness, perceived enjoyment and objective usability (Venkatesh & Bala 2008). These are influenced by the use and experience of the system over time, which eventually moves technology acceptance to technology adoption (Venkatesh & Bala 2008; Pohlmeyer et al. 2009). User experience and especially positive or negative emotional affect towards the system during use, have been found to be related to perceived usefulness and to play an important role in the adoption of technology (Partala & Saari 2015). However, for user experience to be positive the system in use has to meet the basic needs of the user and to fulfil expectations in respect to utility and usability

besides hedonic aspects and psychological needs (McLeod 2018; Duval et al. 2010; Partala & Saari 2015).

2.2.3 Designing Wearable Systems

The first studies into the augmentation and mediation of human senses, intelligence, communication and capabilities as well as human-artefact interaction with computational technology and the development of the first wearable computer date back to the late 1950s and early 1960s (Engelbart 1962; Thorp 1998). The idea behind wearable computing has been to move the technological tools for augmentation and mediation onto the body to create more direct feedback loops between human, computational system as well as the environment (Mann 2001). In their beginnings, wearable systems studied and developed have predominantly been body-worn and centred on functionality instead of incorporating aesthetics (Flanagan 2015), such as the first wearable blackjack system hidden in a shoe (Thorp 1998), head-worn displays and augmented reality glasses, wearable and portable keyboards and hand-held mice (Mann 1997; Starner 2001).

To address the shift from interacting with technology towards mediating human-environment interaction through technology, however, new paradigms for the interaction and design of wearable systems have to be found and new affordances in design to be provided (Mann 2001; Uotila et al. 2006). The necessity of a transdisciplinary approach to wearable design has therefore been proclaimed (Flanagan 2015). A wearable device needs to fulfil several functions, namely to support task performance and fulfil the functional needs it was designed for, as well as to fulfil the psychological needs of its wearer as an item of fashion and self-expression next to general considerations of wearability and comfort (Buenaflor & Kim 2012). User acceptance and in consequence the design of useful and easy-to-use devices that address the users' needs are one of the ongoing challenges in the development of wearable technologies and an essential aspect contributing to the endorsement and adoption of wearable devices (Buenaflor & Kim 2012; Chan et al. 2012; Hanuska et al. 2017). Unlike many other applications in the field of ubiquitous computing (Weiser 1991), which address rather artificial needs and follow a technology centred approach, the design of wearable devices should address a real need of its user and provide a meaningful functionality or service, which constitutes a meaningful use case (Buenaflor & Kim 2012; Hanuska et al. 2017; Duval et al. 2010).

The challenges that the design of wearable systems faces are technological but also related to their physical, functional and psychological design. Research and development into smart wearable systems is therefore an interdisciplinary area of research integrating aspects of design research, human physiology and psychology, as well as fashion and textile theory and technology (Uotila et al. 2006; Suh et al. 2010). Functional challenges include that they are potentially always on, ready and active but at the same time need to remain in the background of their wearers' attention without inhibiting their activities and interaction with the environment

but mediating this relationship and providing services whenever required (Weiser & Brown 1996; Mann 1998). In consequence attributes like ‘unmonopolizing’, ‘unrestrictive’, ‘observable’, ‘controllable’, ‘attentive’ and ‘communicative’ have been associated with wearable computing and its development (Mann 2001). Addressing these functional challenges and resulting psychological challenges out of wearable use and control requires new sets of interfaces and gestures for interaction, which integrate seamlessly into the situational context, are socially acceptable, do not draw attention or make the wearer feel awkward or out of place (Benyon 2014; Profita et al. 2013; Dunne et al. 2014).

To cater for psychological needs in the design of wearable devices, a human-centred approach to development is needed, which incorporates aspects of usability and user experience research (Duval et al. 2010; Rogers et al. 2015). However, little research has been done to date looking at smart clothing and wearable computing from a user-centred perspective in particular in their use in the social and physical context as well as the psychological relationship of its wearer towards a wearable as a fashion item, which has been claimed to improve the usability and acceptability of such devices (Uotila et al. 2006). Looking into the theory of clothing and fashion can help address user needs in respect to the functional, expressive and aesthetic dimensions of wearables (Uotila et al. 2006). The functional dimension encompasses fit, mobility, comfort, protection and wear, the aesthetic dimension includes the design of line, pattern, colour, and materiality, whereas expressiveness is seen in regard to the communicative and symbolic qualities a wearable offers for the expression of self in context and in dialogue with the social environment (Uotila et al. 2006). Key is to create garments or accessories that are adaptable to be acceptable and accessible to a large number of users (Uotila et al. 2006)

2.2.4 A Case for Wearability

One important aspect of wearable systems and devices is that unlike their mobile device counterparts they are in continuous direct contact with the body while being used. This has a great impact on the design of the device and system and requires a different design language. An aspect in the design of wearable systems is wearability. Wearability describes the relationship and interaction between the wearable device, the body, and the wearer, which has to be regarded in a dynamic setting (Gemperle et al. 1998a). Wearability encompasses different physical, physiological, interactional, and psychological aspects of use, usability, and design, which in the form of thirteen guidelines have been described by Gemperle et al. (1998b) as follows: the placement of the wearable on body, a body-centric form language, allowing for movement, taking into account the human perception of what belongs to the body, the size allowing for body size variation, and how it is attached. Physical characteristics of the device to take into account are defined as containment, i.e. the materials and technology it contains, its weight, which affects the movement, placement, and balance. Furthermore, interactional aspects

involve accessibility of the device and its interface, passive and active sensory interaction with the device, and thermal aspects, which can be functional, biological, or based on perception.

A comfort rating scale was developed to be able to determine the comfort of a wearable device along six different scales: emotion, attachment, harm, perceived change, movement and anxiety (Knight et al. 2002; Bodine & Gemperle 2003). Research has also been conducted into the areas on the body that best allow for the placement of technology but also for integrating sensing to maximise the wearability of the devices as discussed previously (Wilson 2005). The area around the core body was established as the best area for sensing, while the best location for the placement and fastening of wearable devices are around the limbs or torso.

How the interpretation of aesthetic qualities of a wearable by others is perceived by a user is key to so-called aesthetic wearability and affects the user's acceptance of the product (L. E. Dunne et al. 2014). In general, wearable devices have been found to transcend models of acceptance for technological systems, behaviour change and fashion trends, thus adding aesthetic and emotional values and aspects of self-image, which are related to the user experience, to a more functional mix, such as perceived usefulness and ease-of-use (L. Dunne et al. 2014).

2.2.5 Towards Personal Wearable Solutions for Individual Thermal Comfort

Over time, adaptive solutions have been developed, which enhance and thus provide control over individual thermal comfort independent of existing building systems and structures. These range from the most basic form of layering and adapting clothing to the use of heated bricks and hot water bottles with an aim to bridge moments of discomfort, the gap between environmental conditions and individual needs. However, most of these solutions are very often restricted to private use or different usage contexts outside the office environment. Dress codes limit the adaptive capabilities of occupants further, although the ability to adjust clothing levels has been shown to be an effective and energy-efficient way of managing thermal comfort on a personal scale (Newsham 1997). Wearable technology, and in particular smart clothing, has in general been hailed as a step towards providing independence from centralised infrastructures and addressing individual needs based on contextual requirements (Mann 1996).

Research and development into wearable and portable personal micro-climates have so far primarily been conducted in regard to applications for extreme conditions, such as under water, in extreme heat or cold, or outer space, or for special use cases, such as in sports, medicine, military or in thermally stressful workplaces, such as firefighting or the arctic (Rantanen et al. 2002; McCarty 2005; Yazdi & Sheikhzadeh 2014; Teunissen et al. 2014). In addition, the main focus of enquiry lay on the effectiveness and efficiency of the solutions to alleviate heat or cold stress of the users (Wang et al. 2010; Yazdi & Sheikhzadeh 2014).

Wearable devices to reduce thermal stress target primarily physiological needs (Duval et al. 2010). However, applications in extreme or hostile environments present different challenges for personal thermal solutions compared to non-extreme, every-day conditions.

Therefore, in recent years research in PEC systems has been extended to include wearable devices for thermal comfort. Studies have been conducted both with a focus on wearable personal heating as well as wearable personal cooling. Research into wearable personal heating has looked, for example, at heated gloves and core body warmers for outdoor work in the cold using either chemical, electrical or combustion systems to generate heat (Risikko & Anttonen 1998) or at heated clothing, in particular jackets, to improve thermal comfort of office workers (Udayraj et al. 2018) or of students in unheated classrooms in rural areas of China (Song et al. 2015). Heating technology employed has furthermore involved electrically heated solutions (Song et al. 2015).

Studies on personal cooling have, for example, focussed on cooling vests with phase change materials (Itani et al. 2017) or cooling jackets with a ventilation system (Zhao et al. 2013) to improve comfort for workers in hot outdoor climates, wrist-worn devices or gloves to improve the performance of athletes based on a vacuum-enhanced water cooling system (Heller & Grahn 2012). Current commercial solutions for individual thermal and environmental comfort target different audiences and application areas, such as health and well-being, outdoor activities and sports (Walker 2013). A mixture of well-being and lifestyle device has been released in form of the Embr Wave (Embr Labs 2018).

The majority of available studies on wearable thermal devices to date were conducted in the laboratory and mainly focussed on the effect of wearable thermal devices on skin or body temperature, thermal sensation, and thermal comfort or energy saving aspects under artificial conditions. What has generally been deemed an area for further investigation and a gap in current research are the effects of thermal wearables on the users, for example, in respect to their mobility, experience of wear, as well as the usability of the devices in their actual context of use (Song et al. 2015), as well as the impact of the socio-cultural context and user appropriation on the use of these devices (Udayraj et al. 2018). It has been argued that the application of thermal wearables in real-life is, for example, inhibited by existing dress codes in office environments (Vesely & Zeiler 2014). The question of power supply and with it usage duration and efficiency, size and wearability has been a challenge ever since the beginnings (Starner 1996; Starner 2014). Furthermore, researchers have established the application of smart automated control in combination with PEC and wearable systems as an area of further investigation (Vesely et al. 2017; Udayraj et al. 2018).

Previous research in the field has not included a critical review of the use and usability of the wearable devices and the impact on perceived thermal comfort and satisfaction in their context of use. This neglect is important to address, as the use of devices and the behaviour of people in real world settings is the major confounding factor for the acceptance of technology

(Buenaflor & Kim 2012). In consequence, current research in the area of wearable devices for thermal comfort lacks a human- and design-centred perspective and would benefit from the introduction of HCI and wearability related research agendas to transcend the predominantly engineering centric view on the topic.

2.3 Summary

The increasing interest and amount of research in thermal comfort in the past decades has led to a common understanding that a more adaptive and holistic approach to the provision and evaluation of thermal comfort as well as the development of new solutions for its implementation in practice are needed. The perception of thermal comfort and what is comfortable has been found to be highly subjective and to vary considerably between occupants. Individual differences, such as age, gender, physiology and clothing levels, past experiences and expectations have been found to play an important role alongside other aspects, such as the perceived availability of control opportunities. Although research and development of PEC and a stronger focus on field research have been hailed as ways to address these challenges, progress has remained slow and issues have continued to prevail. A paradigm shift is needed away from the engineering-based approaches and focus on building system level solutions of the past towards investigations into solutions on a more personal scale, from a human-centred perspective, and under real world conditions.

To make thermal comfort more adaptive to individual needs as well as in respect to the increasing interests and rapid developments in the wearable, MEMS, e-textiles sector the sector might benefit at looking at personal wearable and portable solutions. In turn, developments in the field of wearable devices have so far mainly focussed on monitoring applications and body-worn information and communication technology systems, less on addressing functional and physiological needs. Expanding the field to combine thermal comfort, wearable technology and user-centred design can support individual comfort and mediate the human environment relationship on a new level to provide novel user experiences and improve perceived comfort in shared spaces with little environmental control available to the individual.

The challenges for the development of personal thermal systems consequently lie in the combination and overlapping of the three domains, i.e. the design, development and usability evaluation of wearable and portable technologies to increase individual comfort in existing open-plan work environments. It has been concluded that a user-centred design process based on methods from human computer action (HCI) and informed by a mix of methods and tools used in thermal comfort research can help address the identified gap.

Chapter 3

Research through Design: Studying Individual Thermal Comfort and Personal Wearable and Portable Thermal Devices in Context

This chapter presents the approach and methodology as well as the methods and tools employed to study and understand individual thermal comfort, how it is experienced and achieved, through the use, usability, and design of personal, wearable and portable thermal devices. To study and understand thermal comfort as well as the factors influencing design, interaction and perception of portable and wearable devices out of the perceived experience of those involved within their context of use, a field study-based RtD approach was used and complemented with mixed methods from both HCI and thermal comfort research to support the investigation.

3.1 Research Through Design: Addressing Thermal Comfort as a Wicked Problem

As has been discussed in chapter 2, thermal comfort is a perceived experience resulting out of the interplay between an individual and their environment, which makes it a highly complex topic to study and design for (Vink, Looze, et al. 2005). Thermal comfort therefore constitutes what in design research has been called a “wicked problem” (Rittel & Webber 1973). Wicked problems refer to problems, which cannot be solved using reductionist and positivist approaches, as the understanding and description of the problem already contains one’s approach for solving it. Traditionally, thermal comfort has been studied from an engineering perspective in controlled environments by reducing the perceived experience to a set of environmental and physiological parameters, which can be measured. Although the need for a more human-centred, situated approach in thermal comfort has been agreed on, studying

thermal comfort in a holistic way is challenging and therefore respective research work remains scarce (de Dear et al. 2013).

To contribute to and advance the discussion, as well as to reframe the problem space and investigate possible alternative solutions in both human-centred thermal comfort research and research into the design of personal systems for thermal comfort, this project proposes to study thermal comfort as a wicked problem through the design of individual wearable and portable thermal devices. In the last ten years, RtD has found increasing acceptance as a method in HCI, which allows to address difficult to solve, under-constrained problems by integrating design processes and design thinking into the research process (Zimmerman et al. 2007; Gaver 2012; Zimmerman & Forlizzi 2014). The design process allows to reframe a problem towards desirable states of reality by producing prototypes, which serve as vehicles to initiate discussion and challenge existing ideas, as well as allow to discover unexpected aspects and to apply theories to a specific context (Zimmerman et al. 2007). The focus of RtD is on the process of designing and evaluating a design artefact and its impact on user experience and use rather than on the prototype as a product (Zimmerman et al. 2007). RtD contributes to the body of knowledge by providing concrete examples for alternative futures and studying the agency of design within the transactional human-environment relationship while drawing from methods stemming from empirical research, behavioural theory, engineering and others (Bardzell et al. 2015; Zimmerman & Forlizzi 2014). RtD is therefore rooted in the third wave of HCI (Harrison et al. 2007).

The artefact can be considered as a mediator between the user and their lifeworld and undergoes several iterations of design and redesign while reframing the problem (Verbeek 2015; Zimmerman et al. 2007). Both the reframing of the problem, which helps to point out and uncover gaps in existing processes, as well as the artefacts and the documentation of their design process have been defined as outcomes of a RtD process (Zimmerman et al. 2007). However, others have attached greater importance on the designed artefact and consider the artefact and its documentation as the contribution to the body of knowledge in design theory and practice (Gaver 2012). The difference between the two stances is constituted in the role of the prototype in the research: the prototype either functions as a research archetype and embodies underlying concepts or design spaces, or serves as a means for enquiry to openly explore problem and solution spaces (Wensveen & Matthews 2014). Common to both is the role of the artefact as a vehicle in research and a mode of enquiry (Bardzell et al. 2015).

In this thesis, design prototypes were employed in the later sense, a vehicle to openly explore problem and solution spaces of individual thermal comfort and the design of personal thermal devices to alleviate discomfort. In as such, these prototypes are related to the so-called 'cultural probes' by Gaver et al. (1999), as the underlying aim was to similarly generate insights on people's lives, their behavioural and adaptive practices as well as the understanding of these in a socio-cultural context (Gaver et al. 2004; Kirk et al. 2010). Although cultural probes have

been linked as a methodology to RtD enquiries (Schofield et al. 2017), through the grounding of this research in thermal comfort, the prototypes employed in the scope of this project were grounded by needs and the necessity to provide respective utility, which limited speculation.

RtD is deeply rooted in HCI with its initial aim being to address wicked problems in this particular area (Zimmerman et al. 2007), however, it is argued here that the approach, which is interdisciplinary in nature, lends itself to investigate and address wicked problems in other fields and to couple investigations across domains. As RtD is situated in the field of tension between design and research practices and a question, which has been addressed, is how to align the two (Basballe & Halskov 2012; Bardzell 2016), the enquiry of problems that span across domains but overlap in terms of the artefact as a design or study object can add relevance to the approach. In specific, by investigating wearable design through the lens of thermal comfort and vice versa, the counterpart provides the critical element necessary to study and show its impact on the world, which has been criticised as missing in many RtD studies (Zimmerman et al. 2007).

In line with the principles and criteria of RtD in HCI, this project follows a user-centred design approach in the creation of the design prototypes, focussing on users and their needs in context, empirical measurements, and the development of artefacts in iterative design cycles (Zimmerman & Forlizzi 2014). It is structured along the following basic activities in a design process: the analysis of the problem space and establishment of requirements, the design of alternatives, prototyping, evaluation and reflection (Rogers et al. 2015; Zimmerman & Forlizzi 2014). Figure 3.1 gives an overview of the project and the different phases of development and design cycles it included.

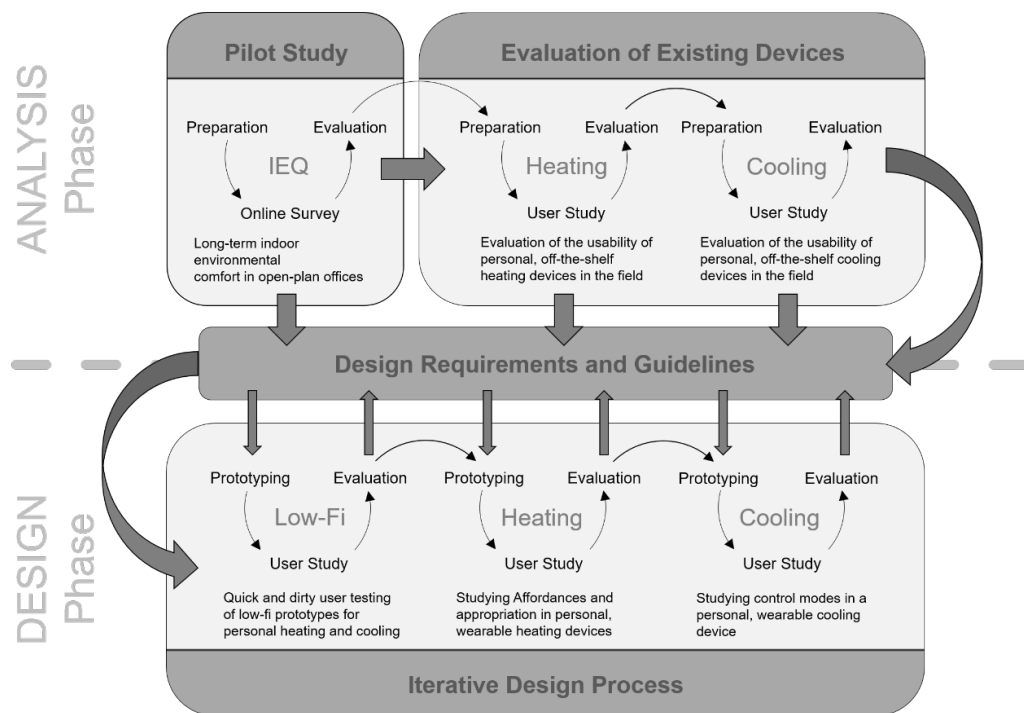


Figure 3.1: Overview of the research project and the cycles of design and development.

In the analysis phase, a short pilot survey was conducted to uncover the parameters responsible for discomfort in shared work environments and verify the suitability of the chosen area of work in the chosen context (see chapter 4). As a second step, a user study was conducted to analyse and study the use and usability of existing off-the-shelf personal heating and cooling devices in the field to establish requirements and guidelines for the design of subsequent prototypes as well as to further establish domains for enquiry and frame the problem space (see chapter 5). The established requirements and domains of enquiry drove the subsequent iterative development of wearable and portable personal devices for heating and cooling, which were conducted in three main design iterations: a user study with low-fidelity paper prototypes and ready-mades to test suitable paradigms for personal wearable and portable heating and cooling devices (see chapter 6), as well as two mid-fidelity prototype development cycles, which facilitated the investigation of the achievement of thermal comfort through affordances and appropriation of a heating prototype (see chapter 7), as well as the trade-offs involved in manual versus automated control modes for personal cooling (see chapter 8).

RtD has been criticised to lack metrics and guidelines to ensure the validity and reproducibility of the research (Zimmerman et al. 2010; Gaver 2012). Furthermore, the thoroughness of the problem framing to contribute to an increase of knowledge through the artefacts, the development of a series of relevant artefacts and a thorough documentation of the design process have been described as challenges (Gaver 2012; Zimmerman & Forlizzi 2014). To address these concerns, a mix of methods both from thermal comfort research and HCI were used in this work to ensure the validity of the research through the triangulation of findings (see chapter 3.3). To support the reproducibility of the research the RtD process is documented in the scope of this thesis. The extensive analysis phase, which included a pilot survey (see chapter 4) and an initial user study on existing devices (see chapter 5), was introduced to provide a thorough framing of the problem space and problem statement of the investigation, both in respect to the achievement of thermal comfort as well as the design of personal thermal devices. Requirements and guidelines derived from the analysis provided the base for the development of relevant and suitable design prototypes and the framing of the investigations presented in chapters 7 and 8, which were further grounded through the testing of initial design ideas in a low-fidelity user study (see chapter 6).

3.2 Field Studies: Studying Artefacts in the Wild

Both in thermal comfort research as well as HCI, field studies or studies in the wild are conducted to study and evaluate interactions between people, devices or the built environment more holistically in a real-life setting (Koskinen et al. 2008; de Dear et al. 2013). Lab-based studies have been criticised to only capture a limited range of interactions between a user and a

device or a user and his thermal environment (van der Bijl-Brouwer & Dorst 2017; de Dear et al. 2013). As artificial environments, they lack the richness of the real-world context and consequently the richness of the constraints and disruptions that characterise the physical, functional and social real-life environment, and which affect and become part of the interaction (van der Bijl-Brouwer & Dorst 2017).

In HCI, field studies or field trials are, for example, used in the development and the usability evaluation of mobile devices and systems (Duh et al. 2006; Rogers et al. 2007). They are the primary research tool if subjective assessment and experience as well as behavioural aspects in respect to the interaction with devices in the context of use are studied (Rogers et al. 2007) or if the artefacts to be studied are ambiguous and allow for multiple interpretations (Koskinen et al. 2008). It has been argued that the actual use of an artefact, the interpretation of its use and the meaning making process of the user can only be studied through the introduction of the artefacts into a real-life context (McCullough 2004; Harrison et al. 2007; Redström 2008).

In thermal comfort research, field studies have been described as a simple and practical method to investigate thermal comfort more holistically, as transient real-life conditions are considered (de Dear et al. 2013). As a "*subjective phenomenon*" (Vink, Overbeeke, et al. 2005, p.8), thermal comfort cannot easily be predicted and can in the scope of the experience of an object or environment only be evaluated by the persons using it in a setting which resembles the real-life context as closely as possible (Vink, Overbeeke, et al. 2005; Vink, Looze, et al. 2005). The advantage of the approach is that it does not need "*invasive measurements or tiresome experimental routines*" (Humphreys 1995, p.4), such as studying physiology, body cycles or metabolic rates of occupants or measuring and calculating the heat exchange between body and environment to gain insights on the spatial, conditional and clothing habits of the users, their behavioural adaptation measures and the personal evaluation of their conditions and preferences (Humphreys 1995).

Field studies have been criticised to be costly and time-consuming and for providing not enough additional value in return for the effort undertaken (Kjeldskov et al. 2004). Further disadvantages of field studies include the limited control over environmental conditions and the lack of precision of many field measurements techniques as well as of validity due to a lack of common standards (Oulasvirta 2012). However, designing research for context of use and perceptual relativity by studying real people in real life contexts enhances the external validity of the research (de Dear 2004). In consequence, data gathering methods such as questionnaires, interviews, diaries, and observations have been in use to collect "*soft qualitative aspects*" (Kvale 1994, p.163) on the users' lived experience and creation of meaning through actions alongside quantitative measurements, which will be discussed more in detail in the subsequent section.

All of the points mentioned above, positive as well as negative, have to be taken into account in choosing the right research methods, in the design of tools for data gathering and the overall research design to answer the underlying research questions in HCI as well as thermal comfort research effectively (Rogers et al. 2007; Oulasvirta 2012). If designed carefully, studies in the wild can provide a consistent picture of how thermal comfort is perceived and achieved and allow to obtain insights into occupants' use of and interaction with personal devices in their thrive for thermal comfort in their context of use (Rogers et al. 2007).

A general outline of the study set-up designed for the user studies in the field as part of this thesis can be seen in Figure 3.2. Each of the studies consisted of two parts: the introduction and pre-study part featuring an IEQ questionnaire and thermal background questionnaire to evaluate the general perceived comfort of participants and their satisfaction with different IEQ parameters and the main study, in which participants evaluated a personal thermal prototype or device given to them in different episodes and were asked to report on their perceived thermal comfort and the environmental conditions by filling in a right-now survey regularly. At the beginning of each episode of device testing, participants were given a short introduction to the device, the available settings as well as health and safety instructions. At the end of each episode participants were asked to fill in an evaluation questionnaire to provide feedback on the prototype and their use, which was complemented with an end of study questionnaire or interview at the end of the testing. During the study of existing personal devices (chapter 5), one episode lasted three days, in which one out of five different personal devices was made available to a participant. The main part of the user studies, which were conducted in the design phase of the project (chapters 7 and 8), consisted of three episodes per participant: two days of testing the first prototype or modality, two days of testing the second prototype or modality, and two days in which the participant was free to choose between prototypes or modalities. This no-choice/choice approach is employed in psychology and HCI to find out, which of two options users prefer and choose under which conditions as well as to understand the design and decision trade-offs and reasoning involved (Siegler & Lemaire 1997; Walsh & Anderson 2009; Brumby et al. 2011).

Furthermore, the environmental conditions at each participant's desk space were recorded over the course of the user study using a local network of sensor and device nodes. A sensing circuit attached to or integrated in the prototypes allowed to log device activity. A detailed introduction to the methods used are given in the following subsection.

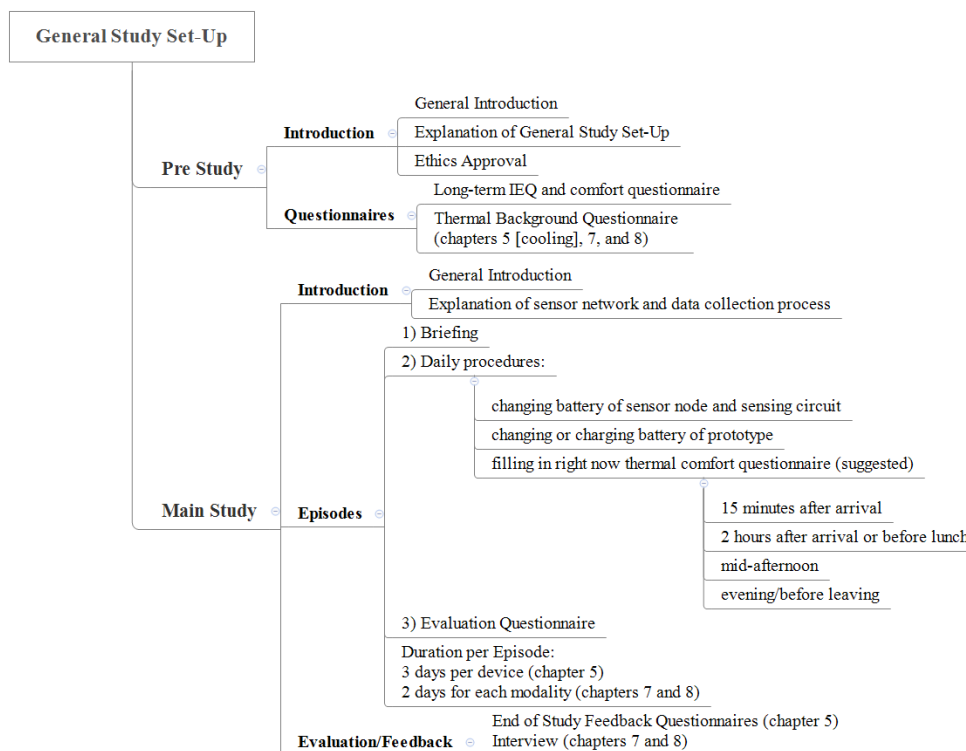


Figure 3.2: Schematic Overview of a General Study Set-Up

3.3 Mixed Methods: Towards a Holistic Understanding of Thermal Comfort by using Design Artefacts

Each research and data gathering method possesses their own particular strengths and shortcomings as well as viewpoint on what is being observed and thus helps reveal a different aspect of reality (Berg 2007). Employing triangulation, i.e. the use, combination and especially relation of multiple methods and therefore perspectives, can help increase the understanding of the aspect under investigation and even out the individual short comings of the tools and methods employed, which reduces the error and therefore increases the validity of the research (Berg 2007).

In this work, methods both from thermal comfort research and HCI, both quantitative and qualitative, were employed to form a transdisciplinary mixed methods approach to study and evaluate individual thermal comfort through wearable and portable design prototypes, as well as to study different design and interaction related aspects including usability, affordances, appropriation, and the sense of control. Combining quantitative and qualitative methods of data collection and evaluation are employed by researchers in these fields to accommodate the collection of both subjective data regarding the experience of participants, as well as objective data in respect to environmental states and device behaviour. A mixed methods approach allows for cross-examination of events and consequently provides a deeper understanding of what is

investigated. In thermal comfort research environmental conditions are measured on location while participants fill in comfort questionnaires (Bauman et al. 1998) whereas in HCI it is common to record interaction logs alongside collecting participants impressions using interviews or questionnaires (Rogers et al. 2015).

To capture the perception and experience of the occupants and users, in this research qualitative and subjective data was collected through indoor environmental quality (IEQ), right-now and prototype evaluation questionnaires as well as interviews. This was combined with the simultaneous collection of environmental data as well as the recording of device activities to relate what was perceived and reported subjectively to objective measurements and to thus provide a deeper understanding of the events and actions. In the low-fidelity study (see chapter 6) talk-out-loud scenarios were employed in the testing of early stage design prototypes. The following subsections give an overview of the methods, which were employed and refined over the course of the investigation. They constitute a toolbox, from which a choice of methods was selected for each study depending on its specific requirements and characteristics.

3.3.1 Questionnaires

Questionnaires are employed widely both in thermal comfort research as well as HCI. In thermal comfort research, surveys are seen as an inexpensive and quick way to assess the satisfaction, health, performance and comfort of the occupants (Peretti & Schiavon 2011). If not focussing exclusively on one or more specific comfort parameters, comfort questionnaires used, for example, in post occupancy evaluation (POE) look at the overall comfort of occupants, which includes peoples' perception of heating, cooling, ventilation, lighting and noise taken together and assessed as one (Peretti & Schiavon 2011). IEQ surveys used in POE try to assess the long-term comfort of occupants. To learn about the preferences and the adaptive strategies of users, their perception and experience in response to their workspace microclimate, right-now surveys in combination with environmental data collection are employed, which establish human thermal comfort and adaptive strategies at a certain point in time (Bauman et al. 1998; Nicol et al. 2012).

The inquiry entails an assessment of the climate of the place, the spatial, conditional, and personal habits of the occupants, and an evaluation of subjective conditions and preferences (Humphreys 1995). However, surveys as tools in thermal comfort research have been critically discussed, as the perception of the occupants and therefore their responses are influenced by the transient nature of comfort and indoor environmental conditions and are based on many factors that cannot all be taken into account (Peretti & Schiavon 2011). It has therefore been suggested to combine questionnaires with other methods of data collection, such as interviews. In HCI questionnaires are employed to help collect information on the use and usability of technology as well as people's experiences, attitudes, opinions and perceptions (Müller et al. 2014). They

are most commonly combined with other methods, such as interviews and activity logs, to evaluate actual use and user interaction, usability and user experience (Müller et al. 2014).

To paint a picture, which would be as holistic as possible, both long-term as well as right-now comfort questionnaires to assess thermal comfort and satisfaction with the workplace alongside questionnaires for prototype evaluation were employed during the field studies.

POE IEQ Questionnaire

No standardised POE questionnaires exist but one of the most widely used survey questionnaires is the CBE occupant indoor environmental quality survey developed by the Center for the Built Environment at the University of California at Berkeley (CBE n.d.; Peretti & Schiavon 2011). It allows to evaluate the long term conditions, issues, the perceived quality of the place, and occupant satisfaction levels with different IEQ parameters, such as acoustic comfort, air quality, cleanliness and maintenance, lighting and visual quality, office furnishings and layout, and thermal comfort (Vischer 2008; Peretti & Schiavon 2011). Participants are asked to rate their satisfaction with these parameters on a seven-point rating scale, from very dissatisfied to very satisfied (see Table 3.1).

Very dissatisfied	Dissatisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Satisfied	Very satisfied
-3	-2	-1	0	1	2	3

Table 3.1: Seven-Point Satisfaction Rating Scale

Furthermore, the perceived impact of these IEQ parameters on the productivity of participants is assessed. Participants are asked how much the quality of a specific parameter enhances or interferes with their ability to get their work done on a seven-point rating scale from greatly interferes to greatly enhances (see Table 3.2).

Greatly interferes	Interferes	Slightly interferes	Neither enhances nor interferes	Slightly enhances	Enhances	Greatly enhances
-3	-2	-1	0	1	2	3

Table 3.2: Seven-Point Impact on Productivity Rating Scale

Although POE IEQ surveys are often depicted as being a measure of the building quality, it has to be pointed out that it is rather the perceived quality of place than an objective quality they illicit and that they help to understand user preferences, likes and dislikes on a more subjective level (Vischer 2008).

The IEQ surveys employed for each study conducted in the scope of this thesis can be found in Appendices A, B, D, and E. The questionnaire used in the pilot survey (chapter 4) constituted a full IEQ assessment, which included temperature, air quality, amount of light, visual comfort of lighting, visual contact with the exterior, level of noise, sound privacy, layout, visual privacy, office furnishings, the level of individual control, cleanliness, ease of interaction, and general work atmosphere. The IEQ questionnaire employed in the subsequent user studies (chapter 5, 7, and 8) used a reduced set of questions, which included the satisfaction rating of different IEQ parameters, but focussed in more detail on thermal comfort and perceived control.

Commencing with the study of off-the-shelf cooling devices (chapter 5) questions on the thermal background of participants were added. This included questions on how participants commonly achieve comfort at home and in the office, whether they can more easily feel hot or cold and which climate they grew up in. It was decided to add this questionnaire to gain an understanding of the behavioural adjustments, with which people achieve comfort, on a more personal level.

Right-Now Questionnaire

Right-now questionnaires have been employed to look at differences and variations between people in respect to perceived thermal comfort. Rather than asking occupants about their more general satisfaction, likes, and dislikes in respect to their environment, the questions focus on the perception, thermal satisfaction and experience in the moment, taking stock of the embodied being, self, and adaptive actions in respect to the environment.

Right-now comfort surveys commonly collect four types of data: physical measurements, the collection of personal variables, subjective measures, and behaviours, of which the latter three are collected in the scope of the right-now questionnaire (Nicol et al. 2012). Personal variables, which are collected, include clothing and activity levels¹. Clothing does not only function as insulation but also reflects the climatic and social situation of the occupants and may as such have an impact on the expressed preferences (Nicol et al. 2012). The activity has an impact on the perception of the thermal environment, which depending on the activity and the change between different activity states can affect the perception of comfort for considerable time, e.g. an hour or more (Nicol et al. 2012).

To evaluate the subjective sensation of the temperature, participants have traditionally been asked to rate their subjective satisfaction with their thermal comfort as a perceived state on a scale from cold to warm and as an affective state from extremely uncomfortable to comfortable on seven-point rating scales, which are described in the international standard ISO 10551 (Nicol et al. 2012; Parsons 2003). ASHRAE or Bedford scales have been in use and

¹ As the look up tables traditionally used to assess clothing levels and metabolic rate have been obtained under controlled conditions in a laboratory setting, Nicol et al (2012) propose to use a description of clothing and activities of occupants rather than the estimate obtained out of look up tables. This has been implemented accordingly in the scope of the studies.

widely applied for the purpose (see Table 3.3) (Nicol et al. 2012; Humphreys & Hancock 2007). In order to reduce cultural and geographic biases in preferences for warm or cool conditions, it has been advised to add a preference vote, such as the three-point rating scale by McIntyre (see Table 3.4) (Parsons 2003; Nicol et al. 2012).

Cold	Cool	Slightly cool	Neutral	Slightly warm	Warm	Hot
-3	-2	-1	0	1	2	3

Table 3.3: ASHRAE thermal sensation scale (Humphreys & Hancock 2007).

Cooler	No Change	Warmer
-1	0	1

Table 3.4: Preference scale by McIntyre (Nicol et al. 2012).

Collecting information on the state and changes of environmental control elements as well as changes in clothing can provide information on the behavioural adaptation processes taking place in the environment (Nicol et al. 2012). The first design of the right-now questionnaire, which was used during the study of existing devices (chapter 5), included the aspects mentioned above and allowed participants to give feedback at one point in time (see Appendix B). The redesigned questionnaire, which was used in the field studies of chapter 7 and 8, was based on a sample long-term comfort questionnaire provided in (Nicol et al. 2012), which allows the collection of comfort information four times per day (see Appendix D). The questionnaires in use during the field studies were extended to include a section in which participants could log the use of personal thermal devices or other behavioural adaptations. In the revised questionnaire this section was extended to allow participants to note any changes in environmental controls and adaptive behaviours.

Evaluation Questionnaires

Evaluation questionnaires were employed to evaluate the use and perceived usefulness as well as the perceived advantages and disadvantages of the prototypes and devices tested during the user studies (chapters 5, 7, and 8). After each episode of testing individual modes or devices participants were asked to provide feedback on their use of the devices. After the last episode in the first user study (chapter 5), an end of study questionnaire was deployed, which asked participants to reflect on more general expectations, suggestions and preferences regarding personal heating or cooling devices. In subsequent user studies, the end of study questionnaire was substituted with a short interview.

The device evaluation questionnaires consisted of a set of open-ended questions, which were combined with a set of scale items. In open-ended form, participants were asked to report on advantages and limitations experienced in the use of the prototypes, behavioural adaptation, perceived changes in comfort while having the device, and suggestions for alterations or

improvements. Furthermore, participants were asked to rate their satisfaction with different usability related aspects, which included rating thermal comfort provision, perceived control, comfort and convenience, effectiveness, flexibility and intrusiveness on a scale from 1 (very dissatisfied) to 7 (very satisfied). This scale item was complemented in the evaluation questionnaire employed in the study of control in wearable personal cooling devices (chapter 8) with the comfort rating scale originally developed by Knight et al. (2002) to assess wearable devices in the adjusted format proposed by Bodine and Gemperle (2003). The prototype evaluation questionnaires employed in the study of affordances in personal heating (chapter 7) as well as control in personal wearable cooling (chapter 8) furthermore asked participants to rate the perceived impact of having had the device on their sense of control over the local environment and perceived thermal comfort. These questions were taken from the IEQ questionnaires and amended to fit the context.

Quantitative Data Analysis

The quantitative data collected in the questionnaires was analysed using descriptive statistics, i.e. calculating the mean and standard deviation of the answers and using bar charts to visualise the results. Furthermore, a T-Test for two dependent means was used to test the statistical significance between the ratings of two different control modes tested in chapter 8 and to test the significance of the order of prototypes and modes tested on device ratings in chapters 7 and 8.

3.3.2 Interviews and Think Aloud Protocols

In user-centred design, interviews are frequently used to explore the topic in question, especially in the early stages of the design process and during background research (Rogers et al. 2015). Also, interviews are commonly used if more detailed and in-depth information on a topic is required (Adams & Cox 2008). Furthermore, they can help to put the perceptual experience of participants into context (Adams & Cox 2008).

In the scope of this research, semi-structured face-to-face interviews were conducted in the user studies and evaluation of prototypes developed during the design phase. The decision to use interviews alongside evaluation questionnaires distributed among participants was taken in response to the shortcomings experienced in the initial user study on existing thermal devices. Although participants had reported on their use of the devices in the questionnaire, the descriptions were not clear enough. For example, it was not clear how and where exactly participants placed the devices on their body. Also, larger adaptive strategies in the context involved and the underlying processes of meaning making, and decision-taking had remained in the dark unless reported in written form.

A semi-structured approach was chosen to allow for flexibility in the conversation and to be able to follow up on points brought up by participants during the interview (Adams & Cox 2008). A set of pre-prepared questions, which were partly the same across participants and partly based on individual feedback previously obtained in questionnaires, were used to retrieve more detailed information on how participants achieved individual comfort through the use of the design prototypes, which adaptive strategies they used, which issues they experienced and to elicit their preference. Accordingly, pre-prepared questions included asking participants to show how they used the prototypes and where they placed them as well as which prototype or mode they used when they were given the choice. Furthermore, participants were asked if they had any suggestions or wishes for improvement in respect to the prototypes or their behaviour. However, this question was frequently adapted to address specific aspects mentioned by participants in their written feedback, asking them to explain issues they encountered, which would provide directions for improvement, or actual suggestions in more detail.

Think aloud protocols were integrated into the interview process as well as used as a stand-alone method during the low fidelity user testing using a scenario-based approach (Carroll 1999). Participants were asked to verbalise their thoughts and actions while using the design prototypes and reflecting on the prototype use by suggesting alterations (van der Bijl-Brouwer & Dorst 2017). During the interview sessions participants were asked to re-enact their use of the devices in front of the camera to obtain information on the behavioural adaptation and usage of the devices. The interview and user testing sessions were video recorded or upon participants' request audio recorded only to capture the verbalised thoughts, aims, and respective physical actions of the participants for documentation purposes.

The richness and validity of the collected data using this approach depended on the participants' awareness and ability to consciously reflect on their actions, decisions, and reasons. Consequently, no unconscious behavioural adaptations could be recorded, as would have been possible in regular field observations. Direct observations in the field were not conducted due to privacy concerns and because observations over the duration of the testing, which took place over several days, would not have been feasible. Thus, the alternative approach using interviews, think aloud protocols and re-enactment helped to observe privacy in the shared space and to limit the amount of generated data.

Thematic Analysis

The interviews and collected think-aloud protocols as well as any responses to open-ended questionnaire sections were analysed using thematic analysis as introduced by Boyatzis (1998) and following the six step process outlined in Braun and Clarke (2006). The aim of thematic analysis is to identify patterns of experiences and attitudes in qualitative data by abstracting it into themes (Adams et al. 2008). It has been further argued that thematic analysis is also suited to analyse interaction (Adams et al. 2008). Initial coding was therefore conducted using a

combination of In Vivo, Process and Causation coding to understand which aspects were important to participants and to capture behaviours, processes and their causes in line with the objectives of the approach (Saldaña 2013).

3.3.3 Environmental Data Collection

Environmental data was collected, as it provides a frame of reference and gives an overview of the climatic conditions of the environment participants find themselves in at a certain point in time. The key environmental parameters measured to describe a thermal indoor environment have been defined as temperature, humidity, and air velocity (Parsons 2003). The choice of measurement instrument and the precision with which measurements are taken, however, are dependent on the aim of the study and the budget (Nicol et al. 2012). Traditionally, environmental measurements in post-occupancy studies are taken at a specific point in time and not over a period of several days continuously, as was intended in the field studies conducted in this thesis. Also, specialised equipment is expensive, and it would not have provided the flexibility to monitor the environmental conditions at different places simultaneously and over a longer period of time. Therefore, a custom wireless sensor network was built to collect the required environmental data. The system was based on the open-source platforms Raspberry Pi, Arduino as well as using XBee Series 1 radio transmitters² for communication. Respective systems have been shown to be low-cost and scalable, as well as to be suitable for a range of monitoring applications (Ferdoush & Li 2014; Abraham & Li 2014).

The sensor network consisted of battery powered sensor nodes to collect environmental data, device nodes to collect device activity information, and a base station to receive and store sensor and device information. Sensor nodes were equipped with a temperature sensor³, a humidity sensor⁴, a light sensor⁵, and a wind speed sensor⁶. They were placed at participants' desks about 1m away from the occupant. In the first study (see chapter 5), an additional sensor node was placed at about ankle height corresponding to the measurements taken in traditional thermal comfort studies in the field, which would take measurements of the environment at the height of head, waist and ankle of a sedentary person (Parsons 2003; de Dear 2004).

Device nodes would collect and transmit device status and temperature information and were attached to the prototypes and test devices. The base station consisted of a Raspberry Pi with an XBee shield, which was positioned within reach of the transmitters and would collect and store the data transmitted by the sensor and device nodes. The sensor network was laid out

² DIGI XBEE S1 802.15.4 modules, <https://www.digi.com/support/productdetail?pid=3257>

³ Temperature sensor LM35CZ, <http://www.ti.com/product/LM35>

⁴ Humidity sensor RHT03, <https://www.sparkfun.com/products/10167>

⁵ Light dependent resistor Norps-12, <https://www.digikey.co.uk/product-detail/en/advanced-photonix/NORPS-12/NORPS-12-ND/5039796>

⁶ Wind Sensor rev C by Modern Device, <https://moderndevice.com/product/wind-sensor/>

as a star formation, with the coordinator collecting the transmitted data of all sensor and device nodes in range (see Figure 3.3).

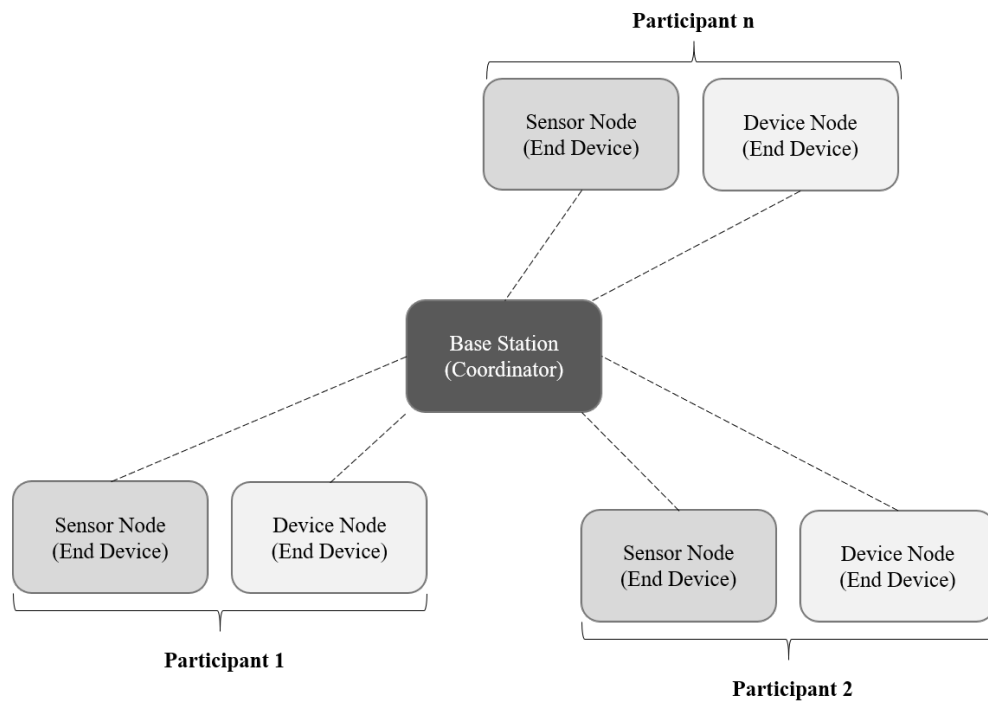


Figure 3.3: Schematic overview of the sensor network.

The sensor network was originally developed for the study testing off-the-shelf heating devices (chapter 5) but due to issues with addressing the humidity sensor in the circuit and thus issues of collecting humidity information, the sensor nodes were redesigned for the study on off-the-shelf cooling devices and used for all subsequent studies with only minor alterations in the software, which regarded adjustments to the frequency at which data was transmitted.

The first iteration of the sensor network used a very simple set-up for the sensor nodes. The sensors were directly connected to the XBee Series 1 pins for data transmission without intermittent microcontroller (Figure 3.4). This worked well for direct data transmission of sensors, which provided constant readings, such as the temperature, light, and wind speed sensor. The humidity sensor, however, required a start signal by the host before sending the readings (MaxDetect Technology 2011). Initially, the idea was to provide the required signal over the network by broadcasting it from the coordinator to the end devices. However, as the address required exact timing, the eventual delay in the transmission over the network did not allow for the level of accuracy required. The first iteration sensor nodes were powered using lithium ion batteries (850mAh), which were replaced every morning while participants tested the devices.

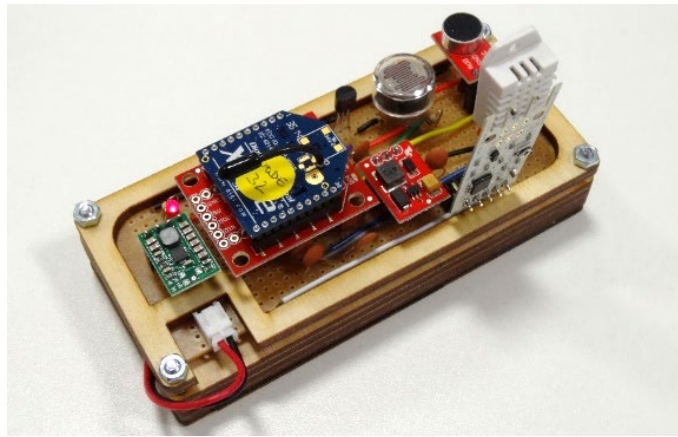


Figure 3.4: First iteration of sensor node used in the study testing the usability of existing personal heating devices.

To be able to address the humidity sensor appropriately, in the second iteration of the sensor network, a microcontroller was introduced into the circuit (Figure 3.5). Due to spatial considerations, a Pololu A-Star 32U4⁷ micro controller running Arduino was used, which offered a limited but sufficient number of inputs and outputs for the application. Unlike in the first iteration of the sensor node, in which the raw sensor data was transmitted, this version allowed to process the sensor data computationally before its transmission. The second iteration of sensor nodes were powered using 5V power banks, which could be plugged in via the micro USB port of the microcontroller. The batteries were plugged in by the participants at the start of their work day and lasted for approximately 8 hours. For both iterations of the sensor nodes the temperature, light and in the second iteration the humidity sensors were tested and calibrated under the same environmental conditions against the readings of a calibrated environment test meter⁸.

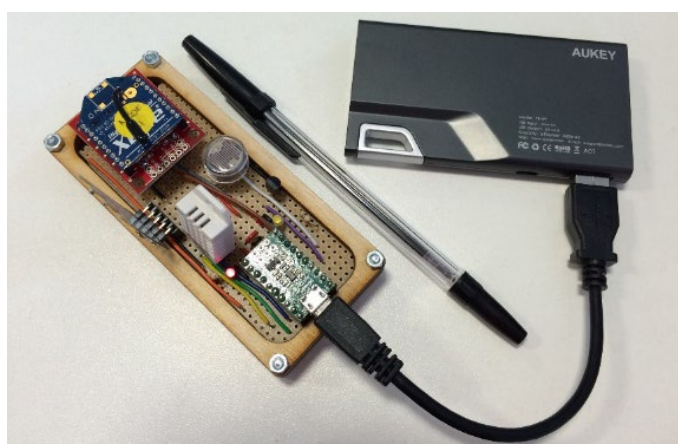


Figure 3.5: Second iteration of the sensor nodes.

⁷ Pololu A-Star 32U4 micro controller, <https://www.pololu.com/product/3101>

⁸ CEM 4-in-1 Digital Multifunction Environment Meter, model DT-8820, <https://www.testmeter.sg/products/CEM-DT-8820-4-in-1-digital-Multifunction-Environment-Meter/18>

The sensor data was collected centrally via a base station, which featured an XBee Series 1 coordinator to connect to the network and function as a transceiver. Raspberry Pis of model A or B+ with an XBee shield served as base stations (Figure 3.6). One Raspberry Pi was placed in each office as long as testing of devices took place. The Raspberry Pi was running a python program to receive and process the incoming data stream. The incoming data was unpacked, and the sensor data was stored locally on a microSD card in a .csv file.

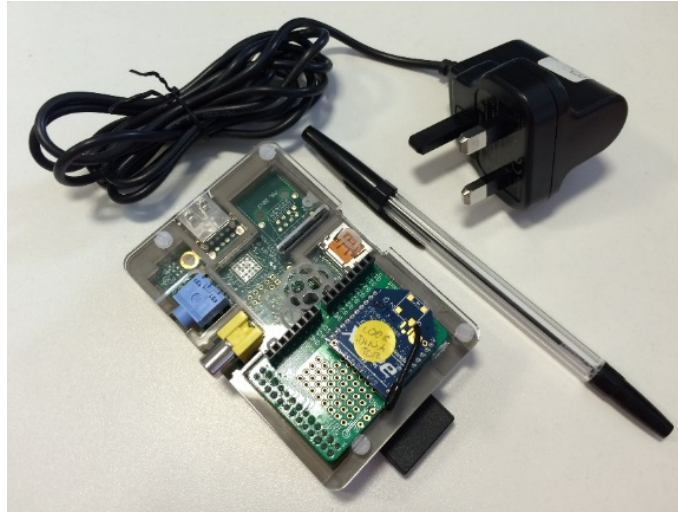


Figure 3.6: Base station, Raspberry Pi Model B+, with XBee shield and XBee Series 1.

The sensor nodes were installed at participants' workspaces over the course of the user studies. In the study of off-the-shelf heating devices (see chapter 5), two sensor nodes were placed and installed unobtrusively both on top and below each participant's desk, at foot, and at mid-body height. In subsequent studies using the updated sensor nodes, only one sensor node was installed and placed on top of each participant's desk. The placement of sensor nodes can be seen in Figure 3.7.



Figure 3.7: Sensor node installation on top of the desk (left) and below at foot height (right).

Time Plots

So-called time plots allowed to visualise the recorded sensor data alongside respective qualitative data collected on the participants' perceived comfort. Plots against time of day provide information about the conditions the occupants have experienced (Nicol et al. 2012). The subjective vote can be plotted against them to visualise the response and reaction (Nicol et al. 2012). The sensor data, which was collected during the user studies, was first cleaned and then brought into shape. As some of the participants shared offices and as consequently their data was stored in a joint file, the sensor data was extracted for each participant and respective device used for each individual day and stored in a separate file. The data was then read into an R program and recorded temperature and humidity information plotted as a time series. The time series was then overlaid with the self-reported rating of perceived thermal comfort of the participant at different times during the day as well as recorded device use as part of the activity log (see Figure 3.8).

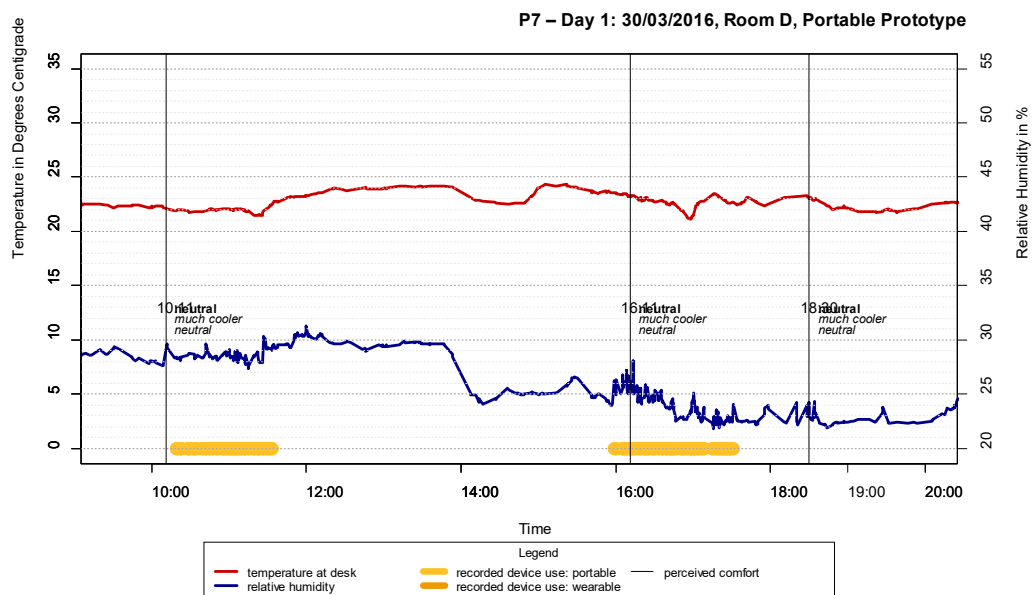


Figure 3.8: Time-series plot of temperature and humidity information overlaid by reported individual thermal responses of a participant and recorded device use over the day.

Furthermore, any reported environmental issues, activity levels, food or drinks, and any behavioural adaptations as well as comments that were collected alongside perception ratings helped to build a holistic picture of perceived individual comfort over the study period.

3.3.4 Activity and Device Logs

Interaction and activity logs are a method used in user-centred design to collect information on the use of and the interaction with prototypes during evaluation (Rogers et al. 2015). Depending

on the characteristics of the prototype and the nature of interaction, this can mean logging acceleration data to retrieve and monitor activity or the logging of user input and device states and settings (Rogers et al. 2015). Together with the gathering of environmental as well as subjective data, the interaction and activity log can provide a more holistic picture of actual device use. In the scope of the user studies conducted and described in chapter 5, 7 and 8, primarily device states including on/off and control modes as well as temperature sensor data were collected. Participants were instructed to switch on the devices prior to use and switch them off after use. In consequence, the data collected also allowed to estimate the duration of use.

To collect activity information, off-the-shelf study devices and the prototypes of the heating study were equipped with a LilyPad temperature sensor⁹ and a LilyPad XBee breakout board¹⁰ for data transmission (Figure 3.9). LilyPad is based on the Arduino platform and allows the easy prototyping of wearable, technologically-enhanced devices and smart clothing (Buechley et al. 2008; Buechley 2013). The device sensing circuit employed during the user studies on existing personal devices and the study of affordances and appropriation using two different heating prototypes was powered independently from the circuit providing thermal comfort using a lithium ion battery.



Figure 3.9: Device node - LilyPad circuit including XBee, temperature sensor and power supply sewed onto a study device.

The sensing circuit for the cooling prototype of the user study described in chapter 8, which looked at control, was integrated. It featured a microcontroller circuit using an ATtiny85 chip (Figure 3.10). The activity information collected encompassed environment temperature, cooling setting, and control mode. Transmission of sensor data and device states via the XBee

⁹ LilyPad Temperature Sensor, <https://www.sparkfun.com/products/8777>

¹⁰ LilyPad XBee breakout board, <https://www.sparkfun.com/products/12921>

was automatically started when the prototype was switched on. The sensing and transmission circuit was also powered off the prototype's 12V power supply.

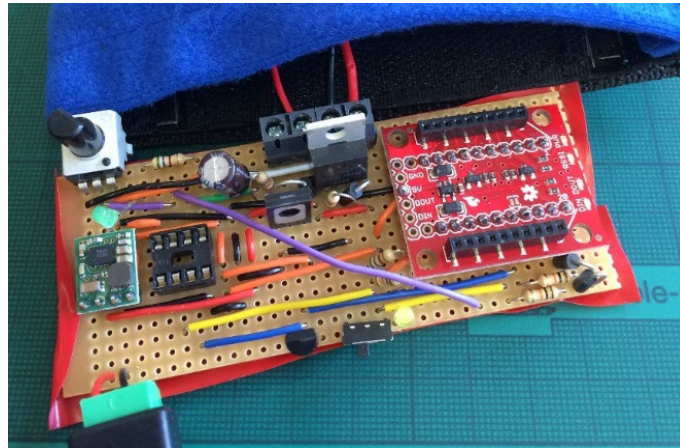


Figure 3.10: Integrated control and sensing circuit of wearable cooling prototype (chapter 8).

3.4 Summary

This chapter gave an overview of the approach and methodology as well as the methods and tools, which were employed in the studies undertaken as part of this thesis. To study and understand thermal comfort as well as the factors influencing design, interaction and perception of portable and wearable devices out of the perceived experience of those involved within their context of use, a RtD approach was employed and complemented with transdisciplinary mixed methods from both HCI and thermal comfort research to support the investigation in the field. Chapters 4, 5, 6, 7, and 8 will show how the approach and the methods were applied in practice. The implementation of the approach and methods and its limitations and shortcomings will be critically reviewed in chapter 9.3.

Chapter 4

Understanding the Context: A Pilot Survey on Indoor Environmental Quality

This chapter presents the findings of a pilot survey on the environmental comfort experienced by occupants in open-plan offices at the School of Electronic Engineering and Computer Science at Queen Mary, University of London. The survey was conducted in preparation of subsequent field studies (see chapter 5, 7, and 8) to better understand the context as experienced by potential future participants. In particular the aim was to find out, which IEQ parameters affected individual comfort most and which additional problems occupants reported facing in their workplace in respect to achieving individual comfort. The following subsections will first give an overview of the setting, in which the pilot survey and the subsequent studies in chapters 5, 7 and 8 were conducted, before introducing the approach and methodology of the pilot survey. Subsequently the findings of the survey are presented and discussed.

4.1 The Setting

The pilot survey as well as the subsequent field studies, which will be presented in chapters 5, 7 and 8, were conducted in open-plan offices at the School of Electronic Engineering and Computer Science at Queen Mary University of London, which is located on Mile End Campus in London's East End. Workspaces for academics and PhD students at the school were spread over two buildings, the Peter Landin Building (Computer Science, CS) on Godward Square, which was built in the early 1970s, and the Electronic Engineering Building (Eng) at Mile End Road, which was built in the 1950s. With 75% of the UK's existing building stock (effective 2002) constructed prior to 1980 (Pout et al. 2002) and with a replacement rate of non-domestic buildings in the UK at only 1-1.5% per year (Delay et al. 2009), these sites can be considered representative examples of office buildings and indoor environments encountered by occupants in the UK at the time of writing, although details between individual buildings might vary.

The Electronic Engineering Building consisted of three interconnected building parts along Mile End and Bancroft Road. At the time the studies were conducted, it possessed an air conditioning system with wall vents, which in selected refurbished offices and workspaces

could be controlled locally. In most offices in the building, however, desk fans were used for cooling. The heating system of the building was centrally controlled but the setting of individual radiators in the offices, which were connected to the building heating system, could be manually adjusted. A limited number of offices on the third floor of the north wing of the building were not connected to the building HVAC system and were heated using mobile electric heaters during winter. The Peter Landin Building also possessed an air conditioning system, which featured centrally controlled ceiling vents in the offices, as well as an additional central heating system with built-in radiators underneath the windows.

The offices in both buildings were being refurbished in stages so that occupants encountered different local workplace conditions, different heating and cooling systems as well as different opportunities for environmental control in different offices. The building systems as well as its structure had not been refurbished at that point so that both buildings suffered from low levels of insulation. Both buildings featured single glazed windows or, in some instances in the Engineering Building, double-layered windows. In general, inefficient glazing can affect the thermal environment and perceived comfort of occupants, for example, by causing heat loss during cold periods and discomfort through draughts and cold window surfaces (Barlow & Fiala 2007). Due to inefficient or missing shading, occupants can furthermore experience overheating, glare, as well as hot window surfaces and surrounding surfaces during summer.

Research work conducted by academics and PhD students in these offices can be described as mainly screen-based and sedentary work, although individual task descriptions can vary and can include teaching duties or conducting research in lab or studio spaces. Furthermore, research work is to a large extent individual work and performed independently featuring a variable work arrangement with flexible working hours, attendance, and workplace choices. In general, the nature of today's work has effects on the comfort of office workers. The screen-based nature of work means that occupants are more sensitive towards pollutants, low humidity rates, and air movement in their environment due to a lower blink rate, which reduces the wetness of their eyes (Wyon & Wargocki 2006). Furthermore, sedentary computer work increases the sensitivity of occupants to environmental thermal conditions. It reduces the occupants' scope and thus their ability to adapt to changing thermal needs by increasing or decreasing metabolic heat production through movement or the body surface area for heat loss by changing posture (Wyon & Wargocki 2006). The pilot survey conducted aimed to uncover the parameters affecting the people working in the open-plan offices at the school most.

4.2 Pilot Survey: Approach and Methodology

In July and August 2014, PhD students and postdocs at the School of Electronic Engineering and Computer Science at Queen Mary, University of London, were invited to participate in an

online survey on IEQ in their workplace. Both quantitative as well as qualitative data was collected using an extended POE questionnaire (see chapter 3.3.1) to paint a holistic picture of the existing indoor environmental quality at open-plan workplaces.

4.2.1 Questionnaire Design

The online survey featured an extended Post Occupancy Evaluation (POE) questionnaire, which can be found alongside a more detailed overview of the results and findings in Appendix A. The survey followed a semi-deductive, semi-inductive approach. The design of the questionnaire allowed the gathering of both quantitative and qualitative data. For the quantitative assessment of comfort, participants were asked to rate their satisfaction with IEQ parameters as well as their overall satisfaction with the personal workspace and the general work environment on a seven-point rating scale from 7 (“very satisfied”) to 1 (“very dissatisfied”). The choice of IEQ parameters included the following aspects: temperature, air quality, amount of light, visual comfort of lighting, visual contact with the exterior, level of noise, sound privacy, layout, visual privacy, office furnishings, the level of individual control, cleanliness, ease of interaction, and general work atmosphere.

To allow additional topics to surface as well as to generate a qualitative picture of the comfort landscape as experienced by occupants, two mandatory open-ended questions were included in the survey. Participants were asked to describe in their own words, what they liked and disliked about their workspaces at Queen Mary. Furthermore, participants were given the opportunity to leave comments in respect to the IEQ parameters in question as well as bring up and comment on issues, which had not been addressed.

4.2.2 Participants

Participants were recruited at the School of Electronic Engineering via email invitation. Invitations were sent to mailing lists, which included PhD students and postdocs at the school, as these are the two academic groups, which primarily have desk spaces assigned in open-plan offices.

A total number of 23 PhD students finished the survey, 22 of which answered the questions with their desk space at EECS in mind. Of the 22 questionnaires considered, 12 were filled out by female and 10 by male PhD students. Out of the 22, 18 participants had a desk space assigned in an open-plan office in one of the two faculty buildings on campus, the remaining 4 participants worked in an open study area and workspace on the premises. Twelve out of the students, who had a desk space assigned, worked in the Engineering Building, six in the Peter Landin Building (see Table 4.1). The four participants, who did not have a desk space assigned, indicated that they worked mainly in a studio space in the Engineering Building. In

general, the desks of the participants in the survey were spread across different offices in the two buildings. However, four participants answered the questions for the same office.

Participant	Gender	Building
S1	Female	None assigned
S2	Female	Eng
S3	Female	Eng
S4	Male	CS
S5	Female	CS
S6	Male	Eng
S7	Female	Eng
S8	Female	CS
S9	Female	CS
S10	Female	Eng
S11	Female	Eng
S12	Female	CS
S13	Female	CS
S14	Male	None assigned
S15	Male	None assigned
S16	Male	None assigned
S17	Male	Eng
S18	Female	Eng
S19	Male	Eng
S20	Male	Eng
S21	Male	Eng
S22	Male	Eng

Table 4.1: Gender and Building Allocation of Survey Participants

Participants were asked how much time they worked in average at their assigned or chosen workplace. Work hours spent at the workplace were divided into three categories: frequent use (more than 30 hours per week), moderate use (11 to 30 hours per week), and infrequent use (ten or less hours per week). Ten or 45% of respondents indicated that they worked at their assigned or chosen workspace for more than 30 hours per week, eight or 36% of respondents indicated that they spent 11 to 30 hours per week at their workplace, and four or 18% of respondents that they worked 10 or less hours per week at their desk.

4.3 Results

The following subsections present the results of the pilot survey. They give an overview of the occupant satisfaction ratings, the qualitative responses of participants towards IEQ aspects they like or dislike about their workplace and the use of third places for work.

4.3.1 Satisfaction with Different IEQ Parameters

An overview of the mean satisfaction ratings with different IEQ parameters can be seen in Figure 4.1. The mean satisfaction with the personal workspace as well as the general work environment was rated slightly positive at 0.27 respectively by participants. The IEQ parameters sound privacy (-1.59), air quality (-1.23), temperature and cleanliness (both -0.82) received the lowest satisfaction ratings. Satisfaction with the ease of interaction (mean = 1.32), the amount of light (1.05), and layout (0.64) received the highest positive ratings.

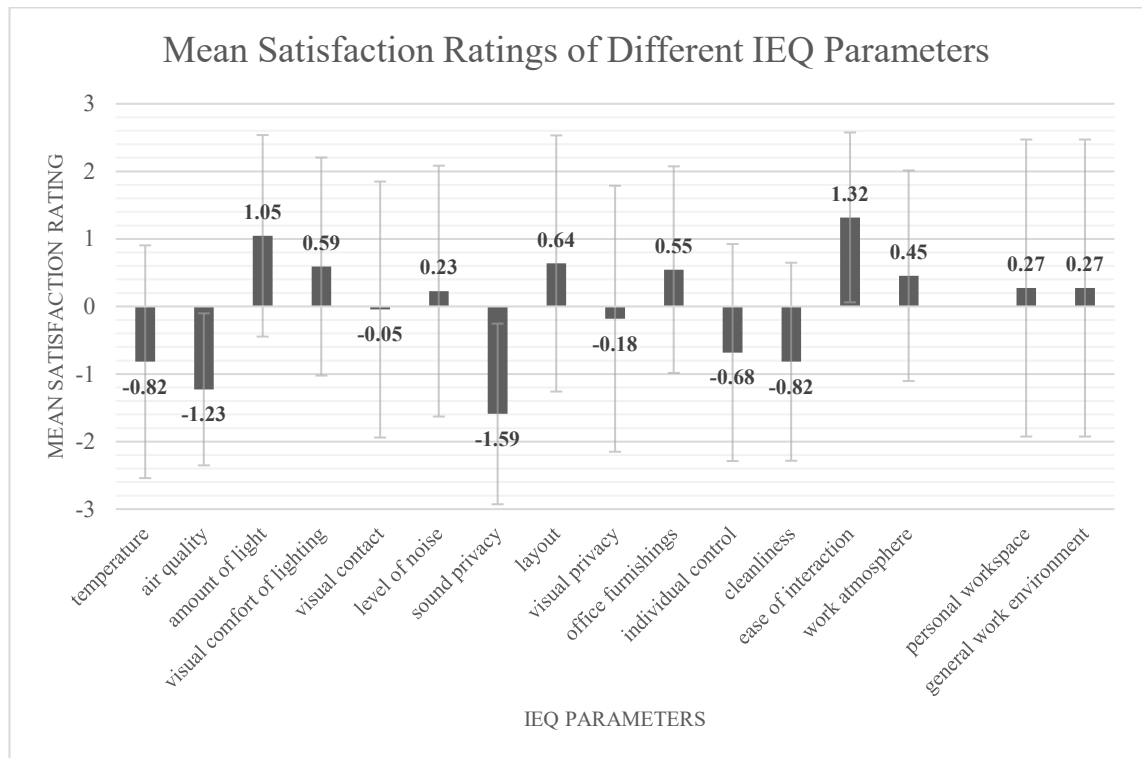


Figure 4.1: Mean satisfaction with different IEQ parameters.

4.3.2 Aspects of Like and Dislike

In the open-ended sections participants were asked to describe in their own words what they liked and disliked about their workplace at Queen Mary in comparison to other places they knew or had worked and studied at before. As the questions were marked mandatory, the answers provided a coherent picture of the aspects that were perceived to be important or issues

by the participants in respect to their workplace environment. The data consisted of short answers, sometimes arranged in whole sentences, but at other times in memo style. The qualitative data was analysed using thematic analysis as described in chapter 3.3.2. As the answers referred to aspects previously addressed in the quantitative survey questions, thematic analysis was mainly performed top-down, as themes and categories had already been established using the set of IEQ parameters described above. However, additional aspects, which had not been previously mentioned or covered by the survey questions, surfaced. This meant that the process of coding also had to be open enough to allow for the emergence of additional themes. The occurrences of the mentions of individual themes were subsequently categorised and counted and can be seen in Figure 4.2.

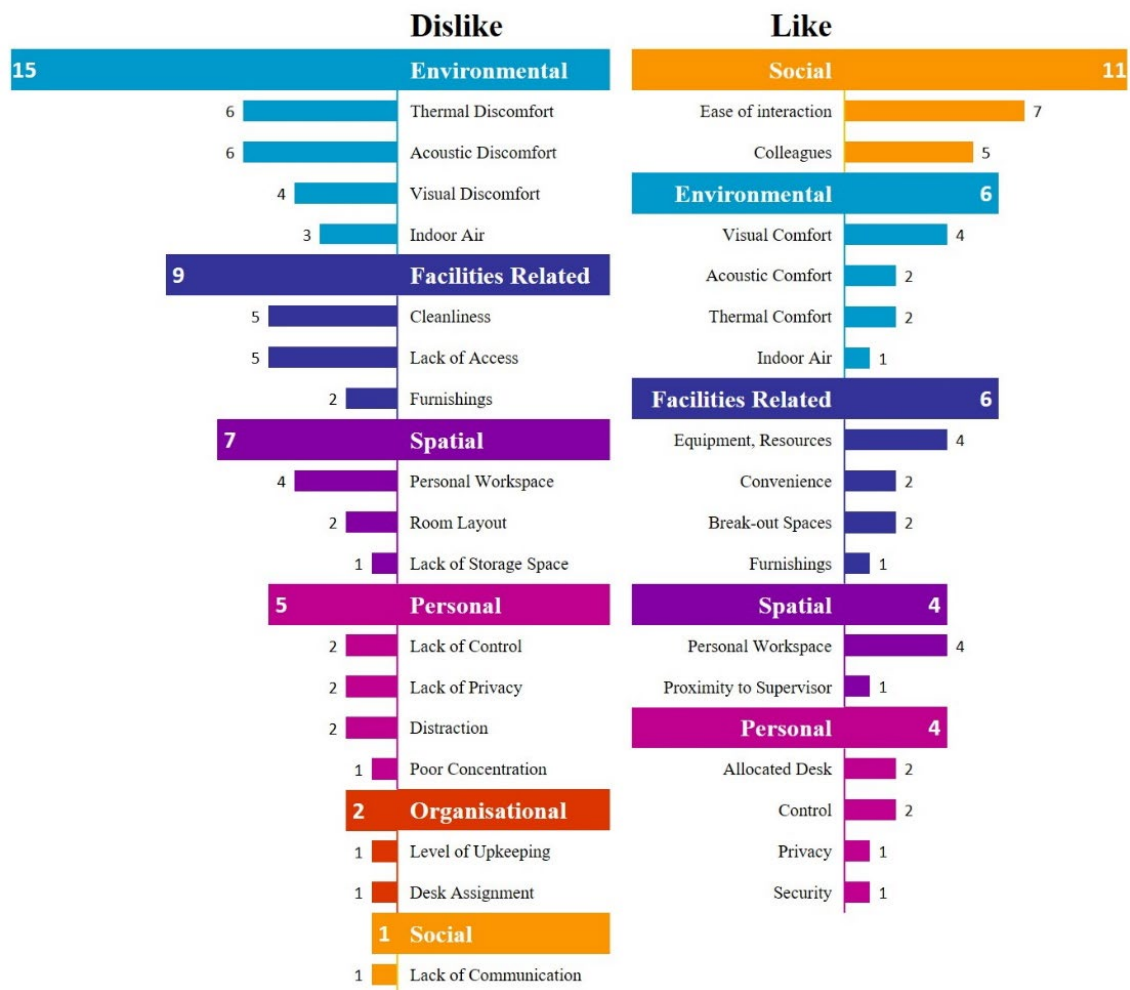


Figure 4.2: Workplace aspects liked and disliked by participants by category and number of respondents mentioning them as well as of related themes by the number of overall mentions.

In accordance with the results from the quantitative analysis, it was also found in the qualitative answers of participants that social aspects, like the ease of interaction with colleagues as well as getting along and liking the colleagues were most often mentioned as positive aspects of the workplace, which were very often balanced against negative aspects of the workplace in the narrative:

“At least I like my office mates as the lighting is poor, we get lots of street noise if we open the windows, my desk is too small for my work with very limited storage space and the room is filled with random crap.” (S18)

“the ease of being able to talk to the person next to you or join discussion, without being frowned upon by others” (S7)

“I am lucky as I sit in a nice office with great views and lots of natural light. I also have good colleagues who know when we all want to work and when we want to chat, or when to take a call or conversation somewhere else.” (S5)

In contrast, environmental factors were most often mentioned as negative aspects affecting the satisfaction with the workplace, which included matters of thermal and acoustic discomfort. In respect to acoustic discomfort the general acoustics, noise and privacy issues were reported, for example:

“Acoustics are awful; I can never hear what anyone is saying. No privacy at all and nowhere to get some privacy if needed.” (S1)

“Layout of room is a bit weird, no dividers or anything that might stop sound travel from phone calls or conversations, so it is very easy to get distracted. There is nowhere to take a phone call really.” (S13)

In respect to thermal discomfort, the indoor temperature, the lack of air conditioning and control over the thermal environment in general as well as the differences between occupants in respect to managing the indoor temperature, for example, by opening windows was discussed:

“Temperature- hot in summer and cold in winter. Lack of control over this and air conditioning.” (S12)

“Mixed personal preference in the office means that while some of us like the windows open to allow for a breeze other people like the heating on high etc.” (S13)

However, one participant perceived that the lack of air-conditioning positively:

“There is only one thing I like- due to a lack of [air-conditioning], the room isn't over air conditioned. We have windows. That is it.” (S18)

4.3.3 The Use of Third Places for Work

Participants indicated that their satisfaction or dissatisfaction with the indoor environment influenced their use or avoidance of their workplace, which reflected in their use of other places to work. Nearly two thirds of participants stated that they used other places for work on campus. Among these so called third places libraries with 13 mentions were mentioned most often followed by cafés and common rooms (7 mentions) as well as workshop (6 mentions) and lab spaces (2 mentions).

A reason for people to choose the workplace instead of a third place for work seems to overlap with the benefits mentioned in the subsection above, namely the interaction with colleagues:

"I go in because it is good to interact with people. I like working at home, but it can get a bit insular." (S5)

4.4 Discussion

The low ratings for IEQ parameters in respect to sound privacy and temperature are in line with the results of analysis of satisfaction ratings undertaken on databases of IEQ surveys from the Center for the Built Environment (Moezzi & Goins 2011; Kim & de Dear 2013). The analysis of survey satisfaction ratings found that sound and speech privacy, noise as well as temperature were the IEQ parameters, for which dissatisfaction was reported most often. The satisfaction ratings of sound privacy (-1.59) and noise level (+0.23) recorded in this study are comparable to results of previous reported IEQ surveys, in which sound privacy received a mean rating of -1.5 for partitioned and of -1.1 for unpartitioned workspaces in open-plan offices and noise level a mean rating of -0.3 and of 0.0 respectively (Kim & de Dear 2013, p. 21). Noise and privacy issues have in general been found to be the main aspects affecting satisfaction with the indoor environment in open-plan offices (Kim & de Dear 2013). In specific, audible but irrelevant conversations have been identified as a source of distraction with a negative impact on performance and mental workload (Smith-Jackson & Klein 2009).

Participants in this study were considerably more dissatisfied with the temperature (-0.82) than was recorded elsewhere, in which temperature was rated closer to neutral with a rating of -0.2 for unpartitioned open plan offices (Kim & de Dear 2013, p. 21). This is important to note, as thermal discomfort has been shown to have negative impact on performance, mood and perceived satisfaction with the indoor environment (Leaman & Bordass 2005; Lan et al. 2011). However, thermal comfort is difficult to achieve in open-plan offices, as variations in thermal comfort responses have been found to depend on age, gender and workplace location (Choi et al. 2012). Satisfaction with the physical work environment has been shown to be related to greater job satisfaction, which in turn suggests organisational well-being (Veitch et al. 2007).

Although a general belief is upheld that open-plan offices in turn better facilitate interaction and communication between co-workers, studies have shown that this is not necessarily so (Morrison & Macky 2017). However, as the results of this pilot survey suggest that open-plan offices have a positive impact on the attitude towards co-workers, which is supported by previous research that found that the degree of liking one's peers is higher in this office form (McElroy & Morrow 2010).

Furthermore, the standard deviation of answers regarding the satisfaction with different parameters over the whole sample population as well as regarded for different subsets of samples proved to be quite high. This indicates that perceived satisfaction varied widely supposedly due to different environmental and spatial aspects participants encountered, as well

as due to aspects, such as the frequency of use, as well as individual personal characteristics, perceptions and experiences.

Based on the findings from this pilot survey it was concluded that individual perceptions in combination with the finding that environmental factors, and in particular so thermal discomfort, are main sources of dislike and dissatisfaction and can provide a basis for further research. The additional finding that to overcome discomfort in their assigned workplace, nearly two thirds of participants reported using other places to work, coping and adaptation mechanisms people employ to achieve thermal comfort in their work place were identified as an additional area for further investigation. In consequence, subsequent user studies (see chapters 5, 6, 7, and 8) took a closer look at environmental and spatial conditions at workplaces of individual occupants and their struggles in achieving thermal comfort, which included looking at possibilities to help overcome thermal discomfort on a personal level using thermal devices.

4.5 Summary

This chapter presented the findings of a pilot survey on the environmental comfort experienced by occupants in open-plan offices at the School of Electronic Engineering and Computer Science at Queen Mary, University of London. The survey was conducted in preparation of subsequent studies in the field to better understand the context as experienced by potential future participants. It found that sound and speech privacy, noise as well as temperature were the IEQ parameters, for which the highest dissatisfaction reported for, both in the rating as well as in the qualitative feedback given by participants in open-ended questions. In contrast, the interaction with colleagues received the highest satisfaction rating and mention. In the light of the additional finding that nearly two thirds of participants indicated using other places to work to overcome discomfort in their assigned workplace, coping and adaptation mechanisms people employ to achieve thermal comfort in their workplace were identified as area for further investigation. In consequence, subsequent user studies (see chapters 5, 6, 7, and 8) included looking at possibilities to help overcome thermal discomfort on a personal level using thermal devices.

Chapter 5

Evaluation of Off-the-Shelf Heating and Cooling Devices

This chapter presents a first interrogation into the design for human thermal comfort, the design of personal devices for use in shared work environments, and the perception of thermal comfort through the use of respective devices. In the scope of two user studies in the field personal, off-the-shelf devices for heating and cooling were tested and evaluated in open-plan work environments. The aim of the studies was to uncover the aspects affecting the use, usability, application and design of wearable, portable solutions for personal thermal comfort in relation to the context of use through the deployment of existing devices into the wild. Retrieving the lived experience of the users using the devices and achieving thermal comfort in their everyday setting lead to the formulation of design requirements and recommendations for the subsequent development of low fidelity prototypes, which is presented in chapter 6, and contributed to the selection of focus areas for further research and subsequent user studies conducted in the field, which are presented in chapters 7 and 8.

The studies featured an exploratory, inductive RtD approach incorporating mixed methods both from HCI and thermal comfort research as outlined in chapter 3. In the following subchapters, the methodology, the results obtained, and the criteria and requirements derived thereof are presented and discussed. This chapter concludes with a summary of the main points.

5.1 Approach and Methodology

The analysis and evaluation of existing devices was conducted in two phases. A user study looking at existing personal heating devices took place during the end of the heating season, in March and early April 2015, and a user study looking at existing personal cooling devices during the summer season, in July and early August 2015. The studies took place over the course of four weeks respectively and both studies featured the same methodology and set-up. However, some of the tools for data collection were updated in between the studies, which will be highlighted where appropriate.

5.1.1 Selection of Devices

The devices used in the scope of the studies were selected for their different properties in respect to size and body locations they could be applied to. For the study on personal heating, commercially available heated gloves¹, a heated shoulder pad², heated socks³, a hot water bottle⁴, and a personal fan heater⁵ were selected, all of which were equipped with a temperature sensor and an XBee Series 1 radio circuit to transmit device temperature information as described in chapter 2 (Figure 5.1). Apart from the hot water bottle, which was filled with hot water by the users, all other personal heating devices featured heat pads or heat strings to generate heat and either ran on battery or had to be plugged into USB or mains.



Figure 5.1: Personal Heating Devices used during the study, from left to right: heated gloves, hot water bottle, heated shoulder pad, heated socks, and personal fan heater.

The off-the-shelf devices deployed in the cooling study were a personal cooling fan⁶, wrist coolers, ankle coolers, a cooling body wrap, and a cooling neck tie⁷ (Figure 5.2). The latter three devices were equipped with a temperature sensor and an XBee 1 radio circuit to transmit device temperature information. Apart from the cooling fan, which ran on batteries and USB, all cooling equipment depended on ice packs for cooling, which were provided to participants at the start of each day of the study.

¹ USB Heating Gloves, <http://www.mobilefun.co.uk/usb-heating-gloves-grey-p11984.htm>

² Beurer HK54 Heated Shoulder Pad, <https://www.beurer.com/web/gb/products/wellbeing/flexible-heating/heat-pads/hk-54.php>

³ Blazewear Heated Socks, <https://www.raynaudsdisorder.com/blazewear-heated-socks.html>

⁴ Large hot water bottle with knitted cream arran style jumper cover, <http://www.amazon.co.uk/Large-Water-Bottle-Knitted-Jumper/dp/B0064NKPBQ>

⁵ De Longhi DCH3030 Fan Heater, <http://www.delonghi.com/en-gb/products/comfort/portable-heating/fan-heaters/dch30301>

⁶ Cool on the Go! personal clip on fan, <http://www.amazon.com/Cool-On-The-Versatile-Hands-Free/dp/B007OWTTAO>

⁷ POLAR Products CoolFit Kit,

<http://www.polarproducts.com/polarshop/pc/viewPrd.asp?idproduct=262&idcategory=430>



Figure 5.2: Personal Cooling Devices used during the study, clockwise from top left: cooling body wrap, cooling neck tie, wrist cooler, personal cooling fan, and ankle coolers.

5.1.2 Study Set-Up

In accordance with the general outline described in chapter 3.2, both parts of the user study consisted of an introduction and pre-study as well as the main study part. In the pre-study part, participants were asked to fill in an IEQ questionnaire on their long-term comfort to indicate their satisfaction with a range of indoor environmental factors, how they used the space, and how comfortable they felt. In the scope of the cooling study, they were also asked to fill in a questionnaire on their thermal background and how they adapted to their thermal environment to ensure their individual thermal comfort in the space.

In the main part of the study, participants were given one of the five personal thermal devices shown in chapter 3.1.1 at a time. The devices were allocated according to availability and so that each device was tested by both genders. At the beginning of each episode of device testing, participants were given a short introduction to the device, the available settings as well as health and safety instructions. They were also given the user manual of the device they were testing for reference in case there was one available. Participants were given the device for three working days and were asked to incorporate the devices as they pleased into their working day and their daily rhythms, which also included the decision not to use a device. During this time, participants filled in right-now questionnaires, in which they were asked to record how they felt and how they would like to feel thermally at that point in time as well as to indicate any changes to clothing. Participants were asked to fill in the questionnaire two to three times a day: shortly after coming in, two hours after that or before or after lunch, and mid-afternoon. Due to flexible working hours, the actual times when the questionnaires were filled in varied between participants.

Furthermore, the environmental conditions at each participant's workplace were recorded using locally networked sensor nodes (see chapter 3.3.3). To record the duration of use

as well as the surface temperature of the devices, participants were asked to switch on and off the sensing circuits attached to the devices corresponding to their use. This applied to all devices apart from the fan heater, whose sensing circuit was sending data constantly. For smaller cooling devices, such as the wrist cooler and the cooling fan the sensing circuit could not be fit on the devices, so their activity could not be logged. Also, not all incidents of device use could be recorded in general, as devices were sometimes out of reach of the base station, participants forgot to switch on the wearable sensors or data drops occurred.

After each episode participants were asked to provide feedback on their device use and its perceived usability. The device evaluation questionnaires consisted of mainly open-ended questions, which also covered behavioural adaptations, perceived changes in comfort while having the devices, and suggestions for alterations. This was combined with a questionnaire at the end of the study reflecting on participants' more general expectations, suggestions and preferences regarding personal heating or cooling devices.

5.1.3 Participants

The data collection for the evaluation of personal, wearable or portable off-the-shelf heating devices took place in March/April 2015 over the course of four weeks. This was a time when heating was still available and weather conditions were still chilly, especially in less sun exposed offices. The evaluation of the usability of personal cooling devices took place in July/August 2015 also over the course of four weeks. Participants⁸ were recruited among PhD students and postdocs at the School of Electronic Engineering and Computer Science at Queen Mary University of London via e-mail. The contributions of individual participants are anonymised and attributed in the text by the abbreviations H1 to H6 for the heating part and C1 to C10 respectively for the cooling part.

In the study on off-the-shelf heating devices all participants were PhD students at the School of Electronic Engineering and Computer Science. Three participants were female and three were male. Five out of six participants were working in an office in the Engineering Building, one in the Computer Science building. Half of participants fell into the age group 26 to 35 years (H1, H4, H5), the other half in the age group of 36 to 45 years (H2, H3, H6). In the study on off-the-shelf cooling devices all but one participant (C3), who was a postdoc, were PhD students at the School of Electronic Engineering and Computer Science. Seven participants were female and three were male. Seven out of ten participants were working in an office in the Engineering Building, three in the Computer Science building. Half of participants fell into the

⁸ The research environment at the School of Electronic Engineering and Computer Science is highly international. Consequently, English was not the first language for the majority of participants, which might reflect in their written feedback. None of the grammar of comments was edited and comments were used as given by the participants. Spelling mistakes, however, were corrected for better legibility and understanding.

age group 25 or under (C2, C6, C7, C8, C10), the other half in the age group of 26 to 35 years (C1, C3, C4, C5, C9). Two additional participants (C9, C10) reported on their thermal comfort during the cooling study but did not evaluate the devices.

Table 5.1 and Table 5.2 give an overview of how the devices were allocated to participants and in which building they were located. Some participants tested several devices. Due to time constraints, each device was only tested by two participants during the studies. The cooling neck tie and the wrist coolers were tested by three participants each. The number of participants testing devices was restricted to five at any one time due to the limited number of available devices and sensors.

Participant	Building	Device 1	Device 2
H1	Eng	Fan Heater	Heated Socks
H2	Eng	Heated Gloves	Hot Water Bottle
H3	Eng	Heated Shoulder Pad	
H4	CS	Hot Water Bottle	Heated Gloves
H5	Eng	Heated Shoulder Pad	Fan Heater
H6	Eng	Heated Socks	

Table 5.1: Allocation and sequence of testing of existing heating devices per participant.

Participant	Building	Device 1	Device 2	Device 3
C1	Eng	Wrist Cooler	Cooling Neck Tie	Cooling Fan
C2	CS	Ankle Cooler		
C3	Eng	Cooling Body Wrap		
C4	CS	Wrist Cooler	Cooling Neck Tie	Ankle Cooler
C5	Eng	Cooling Fan		
C6	Eng	Wrist Cooler		
C7	Eng	Cooling Neck Tie		
C8	CS	Cooling Body Wrap		

Table 5.2: Allocation and sequence of testing of existing cooling devices per participant.

5.2 Results

This section will present the results obtained from the feedback of the participants regarding their experience using the off-the-shelf heating and cooling devices in their work environment

over the course of the study as well as from the collected sensor data. The questionnaires used in the studies as well as the time plots of sensor readings can be found in Appendix B.

5.2.1 Satisfaction with IEQ and Perceived Thermal Comfort

At the beginning of both studies, participants were asked to fill in an IEQ questionnaire to assess their satisfaction with their indoor environment as well as the experienced comfort in their office. The IEQ questionnaire asked about participants' satisfaction with different indoor environmental parameters including workspace layout, furnishings, thermal comfort, air quality, lighting, outdoor and indoor visual aspects, acoustic quality, cleanliness and maintenance. Furthermore, the perceived impact of these IEQ parameters on the productivity of participants was assessed. In the study on cooling devices, participants were asked to fill in an additional questionnaire on their thermal background, which looked at ways people commonly use to achieve comfort at home and in the office, whether they can more easily feel hot or cold and which climate they grew up in.

An overview of the results from the survey from the heating device study can be seen in Figure 5.3. Mean satisfaction was rated lowest for temperature and acoustic related aspects, such as sound privacy, the temperature in general and temperature control, which is in accordance with the findings of the pilot survey presented in chapter 4. Sound privacy was the lowest rated IEQ parameter overall with an average rating of -1.67 on a scale of -3 (very dissatisfied) to 3 (very satisfied), followed by personal control over the thermal environment with -1.17. Participants furthermore indicated that the quality of thermal comfort slightly interfered with their ability to get their work done, followed by issues with acoustic comfort and cleanliness. The ease of interaction was the highest rated IEQ parameter with a mean rating of 1.6. The quality of lighting, general workplace attributes and furnishings were the parameter, which enhanced the perceived productivity most.

Apart from rating their satisfaction, participants were asked to report in more detail on the issues prevalent in their workplace regarding thermal comfort. This included questions about the perceived temperature in their workplace in warm/hot as well as cool/cold weather and which physiological effect this had on them. In the study on personal heating devices, four out of the six participants responded that in cool/cold weather their workspace was too cold (H1, H3, H4, H6). The most often reported sources of thermal discomfort were draughts from windows mentioned by four participants (H1, H3, H4, H6), two participants each mentioned that the air movement was too high (H1, H3), that the heating/cooling system did not respond quickly enough to the thermostat (H4, H6), and that heat from the office equipment provided discomfort (H5, H6). Regarding the physiological effects, four participants reported that in this situation they suffered from cold feet (H1, H3, H4, H6), two indicated in addition that they suffered from cold hands (H3, H4), one that their lower back and kidney area would get cold (H4), and one that their whole body would get cold (H3).

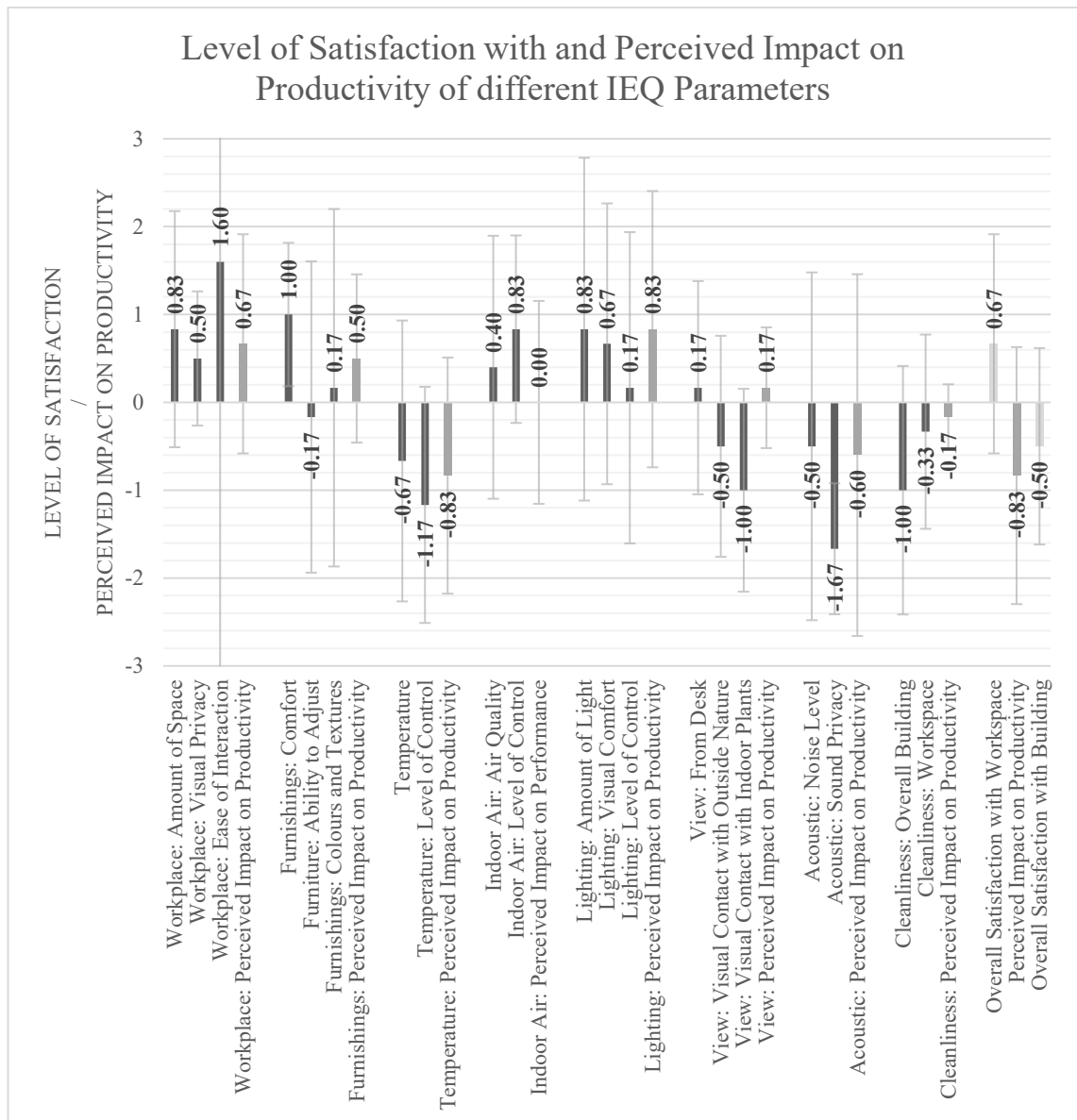


Figure 5.3: Level of satisfaction with and perceived impact on productivity of different IEQ parameters. Results from IEQ surveys conducted during the study of off-the-shelf personal heating devices.

The level of personal control of the thermal environment was the second lowest rated aspect of IEQ satisfaction. In the respective comment section, the lack of personal control over the temperature and the lack of the possibility to control aspects of the environment to achieve thermal comfort were addressed by participants. In the open-ended section on what they would wish for regarding personal control, two participants expressed a wish for more personal heaters (H3) or personal heating (H4) in general. The reason given was being able to operate it without disturbing colleagues (H4). One participant expressed the wish of being able to operate windows and those being double-glazed (H1). Another participant expressed her frustration of the lack of control as follows:

“Ability to do anything rather than just add clothes (or remove. In summer often too bloody hot)” (H6)

In the study on personal cooling devices eight out of ten participants indicated that in warm/hot weather their workspace was often too hot (C1, C2, C3, C4, C5, C6, C7, C10), two of which also indicated that it could also be often too cold (C3, C4). Participants reported the following main sources for their thermal discomfort: six out of ten participants stated that the air movement was too low (C2, C5, C7, C8, C9, C10), four participants each mentioned that the heat from office equipment (C5, C6, C7, C10) or the incoming sun constituted sources of discomfort (C1, C4, C7, C10). In respect to physiological discomforts, four participants mentioned specific body areas that were too hot, physiological conditions, or environmental characteristics that made them feel uncomfortable in warm/hot weather. This included the neck area (C1), the body in general and the feet (C3), which were too hot. Furthermore, one participant reported sweating a lot (C5) and another one stated that draughts made her feel cold (C4).

In the comments section of the questionnaire issues affecting thermal comfort during the summer season with warm/hot weather conditions were brought up. Two participants mentioned that the number of people working in the office affected the thermal quality of the environment (C7), as their bodies would heat up the space (C2), which the participant called a *“greenhouse effect”* (C2). Two other participants expressed the wish for an air conditioning system (C5, C6) and one participant mentioned also the lack of cooling opportunities (C2) as a shortcoming, as the only device available that could be controlled was a fan, which could not cool down the space. In contrast, another participant expressed the wish to limit the area of reach of their neighbours’ fans (C8). More general comments included a wish to change the dates on which the central heating is switched on and off (C10), a wish for less extreme temperatures in the office (C3), as well as a personal office space (C4).

5.2.2 Reported Behavioural Adjustments

The questionnaire used in the study on personal cooling devices included a section on behavioural adjustments. The most frequently self-reported behavioural adjustment to feeling hot in the office was turning on a fan. Six participants (C2, C4, C5, C6, C7, C9) mentioned this as a possible way of relieving heat discomfort. Three participants mentioned avoiding the office (C10) or changing the location (C7, C8) as possible measures. Two participants stated that they would open the windows (C4, C6) or close the blinds (C4). One participant each stated they would have a cold drink (C8) or that they would remove items of clothing (C3), if possible. Getting a wet towel around her calves was mentioned by one participant as a possibility in extreme condition and when wearing a skirt (C4). An overview of the frequency of mentions is given in Figure 5.4.

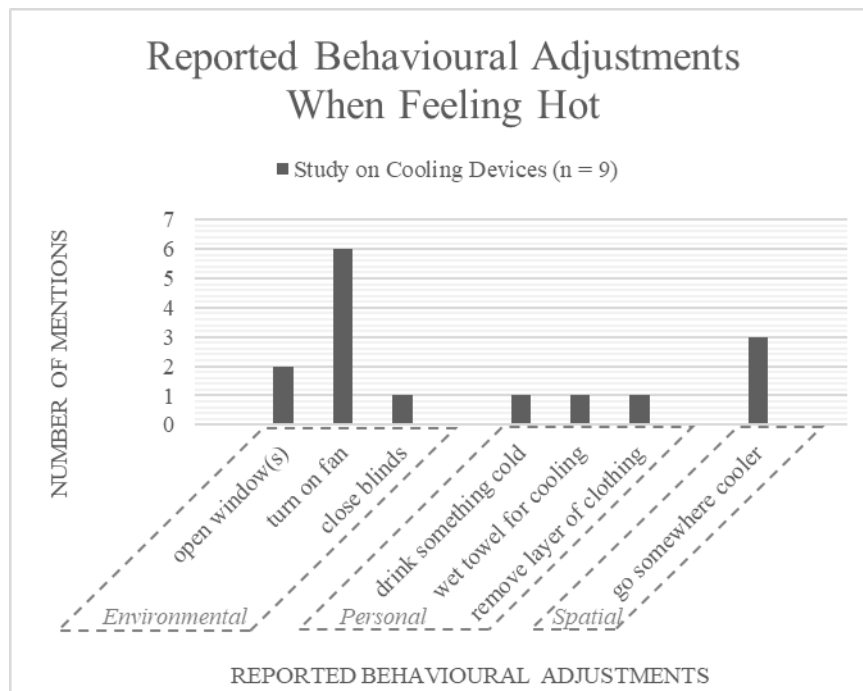


Figure 5.4: Frequency of different self-reported behavioural adjustments when feeling hot (study on off-the-shelf cooling devices).

5.2.3 Time Series Plots: Examples of Thermal Comfort and Behavioural Adaptation

The following section describes individual stories of thermal discomforts experienced by participants during the studies and behavioural adaptations taking place to improve the situation. During the testing of devices, participants were asked to self-report on their activities, clothing, and feeling and perception of thermal comfort as well as on environmental conditions sources of discomfort several times a day using a right now questionnaire. In addition, the environmental conditions at their workplace were recorded. As discussed in chapter 3.3 the recorded data was overlaid in time series plots to better relate temperature information and recorded perceptions. In the following the story of selected participants, H4 as well as C1 and C3, will be reported as examples, which provide an insight into how thermal comfort was achieved. The full set of time series plots of the temperature graphs over time including the qualitative feedback of perceived comfort at certain points in time for each participant can be found in Appendix B.

The office environments participants worked in and the conditions participants had to adjust to at their desk space varied. Most participants' desks except for participant C5 were in naturally ventilated offices in the Engineering and Computer Science building. During the heating season participants' offices were centrally heated via in-built radiators, the temperature of which could be adjusted via controllers. Participant H4 reported adding or removing clothing as an additional means of improving personal thermal comfort during the days she took part in the study. One of the major sources of discomfort she reported was the air movement in her office,

which she described as too high on all three days of testing the hot water bottle and on one day of testing the heated gloves. She attributed it to the fans her colleague had switched on day 1 (at 15:05 and 17:09, see Figure 5.5) and day 2 (at 13:40) of the hot water bottle trial. She added a sweater on day 1 at 15:05 when she reported feeling slightly cool.

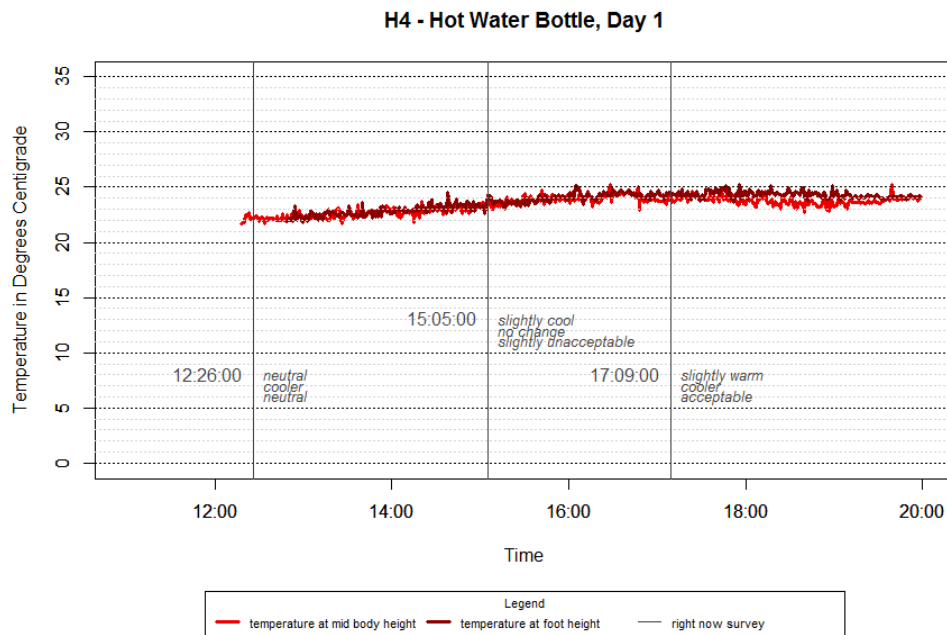


Figure 5.5: Recorded temperature levels at foot and mid-body height at participant H4’s workplace on the first day of testing the hot water bottle.

During the period of testing the heated gloves, participant H4 also reported that the heating system did not provide enough heat (days 1 and 2) as well as that there were drafts from the windows on day 2. According to her outdoor weather description it was a stormy day and that the windows let in the wind (at 12:18) (Figure 5.6). When feeling slightly cool at 13:50 she reported having added a sweater. At 17:08 she stated that her hands were cold. However, she did not report using the heated gloves that day. She only reported using it on day 1 of the test (see Figure 5.6). She criticised at 13:25 that “*device just provides heat for hands not for core body*”, which later was reflected in her evaluation of the device.

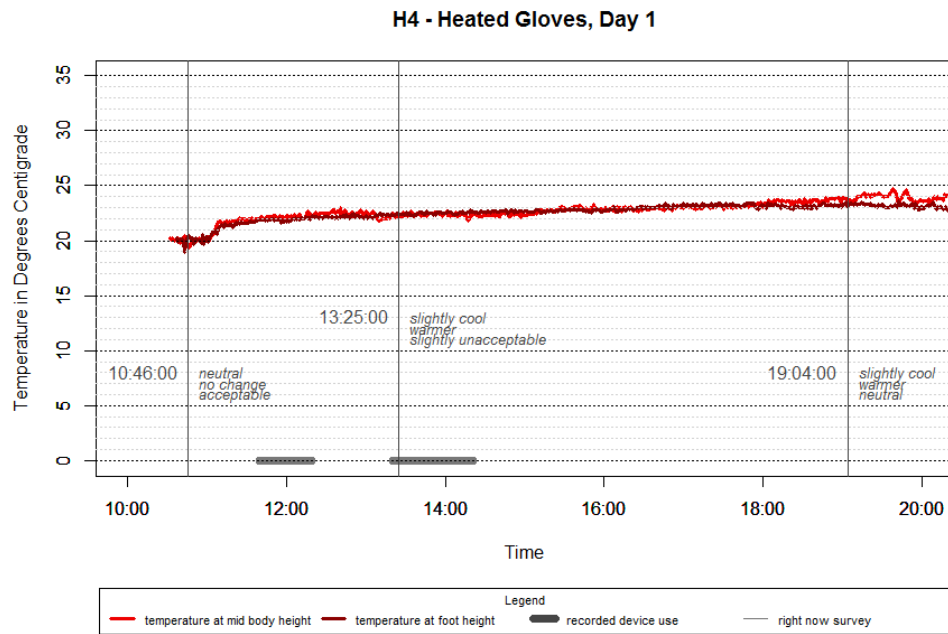


Figure 5.6: Recorded temperature levels at foot and mid-body height at participant H4’s workplace on the second day of testing the heated gloves.

Participants C1, C3, and C6 shared the same office. The individual test periods of participants, however, only overlapped for C1 and C3: The first two days of testing of the cooling fan for participant C1 overlapped with the first two days of testing of the cooling body-wrap for participant C3. Whereas participant C3 wore the cooling body wrap throughout the whole day, participant C1 reported using the cooling fan only at times. However, C3 adjusted the number of cooling packs over time. On the first day, he stated:

“Started with personal cooling device equipped with four cooling packs; successively removed them as I felt it was too cold.” (C3)

In general, the participant reported in the questionnaires that the cooling effect of the body wrap was too strong. This partly reflected in the feeling of comfort he reported over the days. The participant reported twice, on day 2 at 20:53 and on day 3 at 13:56, feeling slightly cool and wished on day 1 at 15:00 to be warmer. On the first occasion this was paired with the reason that there was not enough heating. The participant also reported drafts from the windows on all three days as an issue to his comfort. On the second day, for example, he stated:

“Slightly drafty, as the windows are open for cooling.” (C3, at 16:29)

The opening of the windows and the respective change in temperature and humidity at the participant’s desk can be seen in the temperature and humidity curves in Figure 5.7.

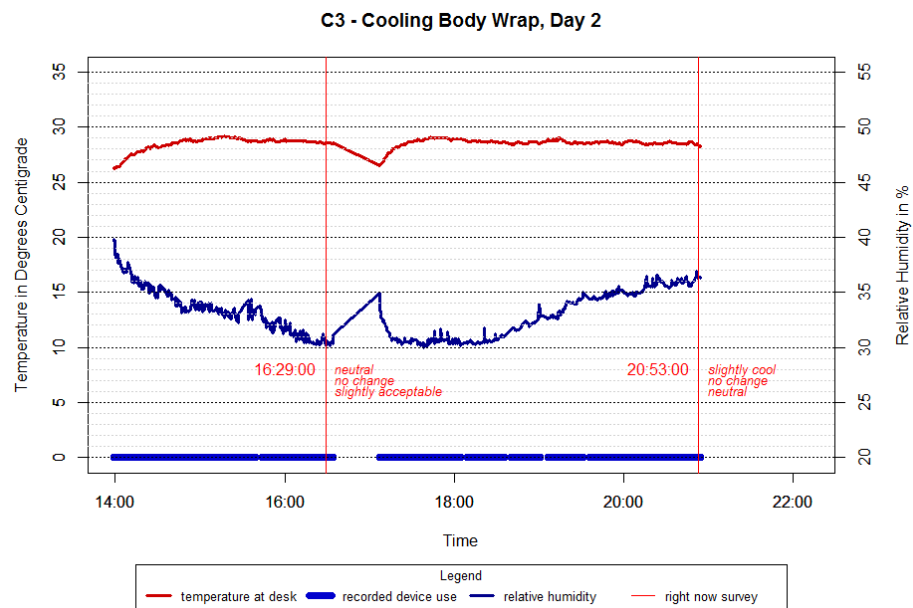


Figure 5.7: Recorded temperature and humidity levels at participant C3’s workplace on the second day of testing the cooling body wrap.

In contrast, participant C1 sitting in a different location in the same office reported feeling slightly warm (14:14) and warm (14:50) during the day due to hot surrounding surfaces (Figure 5.8). He used the fan cooler for cooling. At his workplace the open windows did not have an effect as strong on the recorded temperature and humidity as in C3’s case. C1 was sitting next to a non-operable window and suffered from the incoming sun due to the office facing south. Furthermore, the location of the desk space at one end of the room, next to a wall in the back as well a window on the side, meant that the airflow would not reach there. The participant consequently reported hot surrounding surfaces as issues causing discomfort.

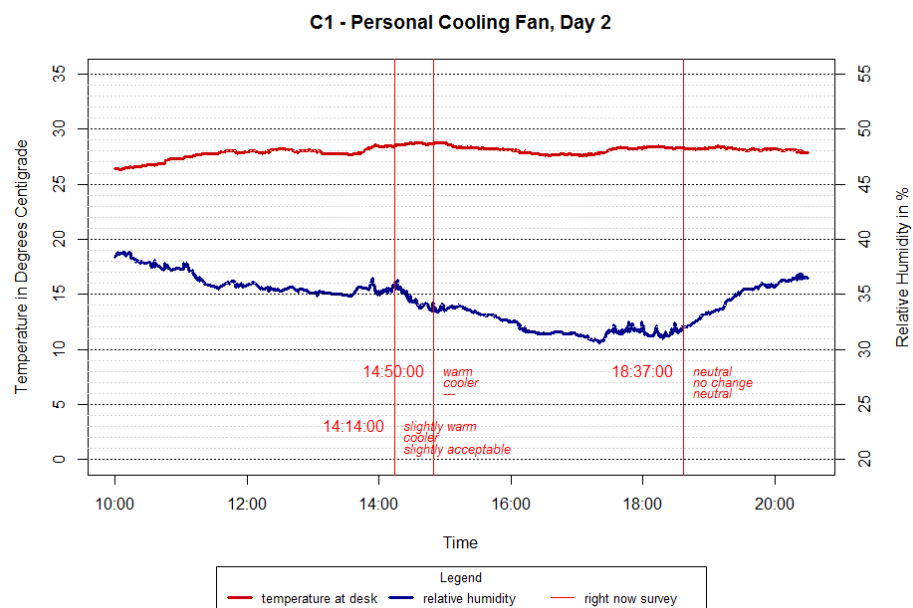


Figure 5.8: Recorded temperature and humidity levels at participant C1’s workplace on the second day of testing the personal fan cooler.

5.2.4 Evaluation of Off-the-Shelf Personal Heating and Cooling Devices

The second part of the study focused on finding out if and how wearable or portable, personal heating or cooling devices supported and increased individual thermal comfort, what issues users encountered using different off-the-shelf solutions in their workplace, what their preferences were, which parameters and attributes mattered. Participants were asked to report on the usability of the devices, any problems and challenges, at the end of the three-day test period in an evaluation questionnaire. In addition, they were asked to reflect on their experiences and compare devices in an end of study questionnaire.

In the following, the findings from this part of the study are presented. The analysis of the qualitative findings across the personal heating and cooling devices tested are thematically grouped into the following areas: usefulness, ease-of-use and usability, perceived affordances, wearability and individual preferences, and context of use. Furthermore, an overview on the duration and patterns of use across devices will be given.

Duration and Patterns of Use

In both studies participants reported different patterns of use. Two participants used the heating devices they were given in the mornings, after having sat at the desk for an hour (H2, hot water bottle and gloves) or shortly after coming into the office to jumpstart thermal body regulation after cycling (H6, heated socks). Another participant (H1) stated using the socks often in the evenings and the fan heater whenever needed. Two participants started but then stopped using the devices (H3 for fan heater and shoulder pad, H4 for heated gloves) or did not use them at all (H4, hot water bottle). The average recorded duration of use of the heated gloves, the heated shoulder pad, and the personal fan heater ranged in between 46 and 48 minutes compared to 114 minutes for the heated socks. Recorded individual uses of the gloves, shoulder pad, and fan heater ranged between 5 minutes up to 1.5 hours and up to 5 hours for the socks. Only one incident of use was recorded for the hot water bottle at 87 minutes. An overview of the variation of recorded durations for different devices can be seen in Figure 5.9.

In comparison, five participants reflected on their use of the devices and reported that they either used the coolers after high activity, for example, after walking to the office, when they started work or during periods they felt hot.

The average duration of use was recorded for the ankle cooler at 62 minutes, for the cooling body wrap at 147 minutes, and for the cooling neck tie at 55 minutes. Individual recorded uses of the devices ranged in between 51 to 73 minutes for the ankle cooler, 27 to 4.75 hours for the body wrap and 2 minutes to 3 hours for the neck tie. No data was recorded for the wrist cooler and personal cooling fan, as the circuits did not fit on the devices. An overview of the durations of use of devices is given in Figure 5.10.

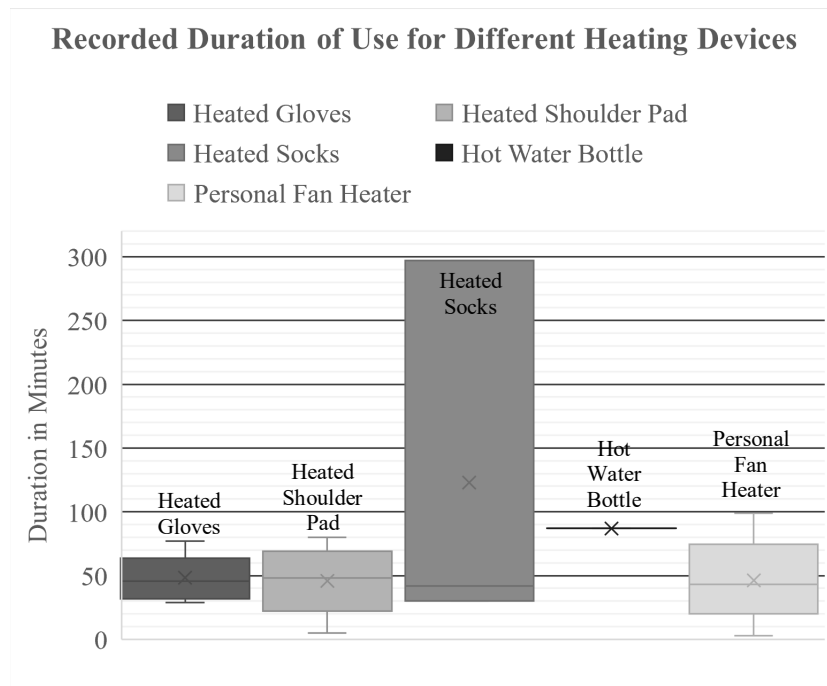


Figure 5.9: Duration of use of different off-the-shelf heating devices.

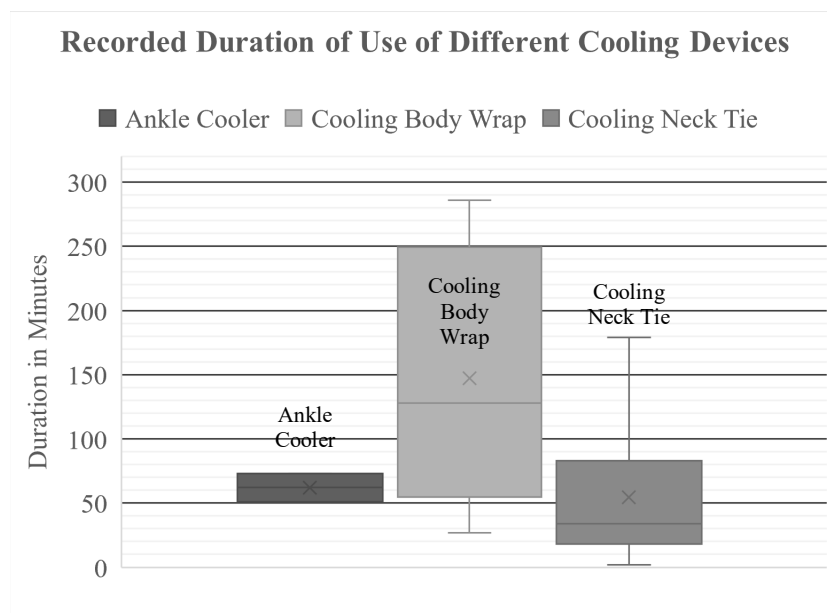


Figure 5.10: Reported duration of use of different off-the-shelf cooling devices.

Usefulness, Ease-of-Use and Usability

The usefulness of devices was evaluated by participants according to their functionality and ability to provide as much heat as was needed, when needed, and where needed. It depended on the amount of heat a device could provide but also on the users' perception at the receiving end. For example, the two users of the heated gloves, H2 and H4, rated the amount of heat it provided either as enough or poor. In general, participants expressed dissatisfaction with the device if the device failed to provide the right amount of heat. Both participants using the fan

heater, H1 and H5, for example, reported that the fan heater provided too much heat. One of the participants stated accordingly:

"The device I did not enjoy using was the personal fan heater, because that device made the air too hot most of the time" (H5).

Both participants using the fan heater also reported their frustration with the heat adjustment due to issues with the usability of the device, in specific with the design of its interface. They could not tell how the setting of the thermostat that could be adjusted would related to the actual room temperature. In consequence, the heater would stop unexpectedly and unintentionally. Also, the ease of use of the device in respect to the ready availability of heat was important. For example, participant H4 noted in respect to the hot water bottle that she did not like having to leave the office to heat water and therefore decided not to use it. The effort of doing so exceeded the benefit she was expecting to receive in return. H2, the second participant using it, reported further difficulties affecting its ease-of-use, such as finding the right sink and sufficiently hot water. Electrical solutions possessed an advantage in this regard, as heating was readily available.

As four out of five of the cooling devices relied on ice packs for cooling, the issues reported by the participants on behalf of the usability and usefulness of the devices. Four participants reported that it was too cold, or the cooling effect was too strong, which rendered the devices unusable at first. However, adaptation processes occurred. Three participants either reduced the number of ice packs in use or they left the ice packs outside the cool box until they were less cold to wear. The effectiveness of the devices was further criticised, as the ice-packs were not only too cold in the beginning but also lost their cooling effect over time, thus providing unstable cooling and lacking temperature control. Participant C7 also mentioned that the cooling was uneven across the surface of the cooling device. Despite the temperature issues, the cooling pack based devices were reportedly more effective in relieving discomfort from heat and in cooling down the body. Five participants reported positively on the effectiveness of cooling. A user of the cooling neck tie, for example, stated:

"The cooling neck tie really helped me to recover the comfort in hot days" (C1).

The wrist coolers were the only cool pack based cooling device for which insufficient cooling was reported.

None of the issues mentioned above affected the battery or USB powered personal cooling fan, which provided a constant air flow while still offering flexibility of use, for example, by using it hand-held. However, a non-uniform air flow was criticised, and its effectiveness was reportedly very low. Participant C5 stated the personal cooling fan did not provide much cooling and relief from heat but the air flow improved comfort:

"the thermal condition did not change much, but the air movement caused by the fan made me more comfortable" (C5)

In addition, both users of the cooling fan, C1 and C5, reported on its noise. But participants' perception of the fan noise was divided. Whereas C1 stated that it was too noisy for him, C5 mentioned that *"personally, a little bit of fan sound makes me more relaxed"* (C5).

However, participants commented positively on the lack of cables of the cooling devices as compared to the heating devices. This, however, came at a price. In the case of the personal cooling fan it meant the fan did not have enough power, which affected its effectiveness and functionality. For all other cooling devices, the ice packs had to be 'recharged' in the freezer, which impacted their ease of use and the ready availability of cooling. As participant C4 stated, having had to get the ice packs from the fridge herself and putting them back after use would have greatly inhibited their use. Jointly with the issue of instable temperature provision, this led to participants' suggestions to employ more permanent cooling packs and to investigate other cooling techniques.

Furthermore, in both studies the control range, i.e. the ability to adjust the strength of the heating or cooling as required as well as providing a stable temperature was reportedly a key aspect in addressing and increasing the usefulness of the devices. The lack of different heat settings was reported negatively for the fan heater (H5) and the heated socks (H6). In turn, the choice of settings and consequently amount of control provided was reported positively for the heated shoulder pad, which featured five different heat settings:

"I enjoyed using the heated shoulder pad because it made me warm in the amount I really needed" (H3).

In addition, participants expressed the wish to be able to control a cooling device remotely or via a mobile app. This was combined with the wish for more discreet control:

"Maybe have the choice to control the temperature from a mobile application to ensure discreetness" (C8).

Participants in both studies also discussed a smart device that would adapt to their body temperature and provide automatic control alongside manual control:

"It would be nice to have a temperature setting. Like a 'smart cooler' adjust the temperature based on people's body temperature" (C2).

"I would like a not wearable device that can predict how cold or warm I want to be, and then automatically the device would take decisions about how to change the environment temperature" (H5).

Perceived Affordances: Versatility and its Impact on User Appropriation, Adaptation and Satisfaction

Other key aspects in the use of the personal heating and cooling devices included the affordances the devices provided in respect to the area of use, i.e. the body location the device covered and to which heat was applied to, and how flexible and easy to appropriate a device was to local conditions and individual comfort needs. All of the wearable devices, the heated gloves,

socks and shoulder pad, as well as the ankle, wrist, neck cooler and body wrap were designed for use on a certain body part, which depending on their form and intended fit limited their versatility and thus the possibilities they afforded to appropriate the device. However, devices were well received if their application area coincided with actual comfort issues experienced by their user, such as cold feet. Accordingly, the users of the heated socks, H1 and H6, reported positively on their use of this device. H1 liked the idea of heated socks and stated that it would be the device he would wish for. Perceived usefulness was inhibited further if a device did not deliver the right amount of heat to the right body location and did not allow for appropriation. For example, H2 did not feel that the position of the heat pad of the heated glove, which was situated at the back of the hand was the right place. He suggested having the heat pad on the palm instead. Accordingly, he stated not being sure about how much the heat pads contributed to his comfort or if wearing the gloves helped him feel warmer at all.

The provision of heat to the right body parts kept reoccurring as a theme and was complemented by the appropriation and adaptation of devices by the participants. Both participants using the heated shoulder pad, H3 and H5, appropriated the device. They used it on the shoulders and legs (Figure 5.11). H3 expressed her ideal heating device in accordance with her preference for the shoulder pad as *“thin and large enough to bend/fold for using on different body parts”* (H3). Both reported positively on the ability to adapt the use of the device to their needs but H5 also mentioned limitations in doing so. He reported suffering from cold feet but could not use the shoulder pad there.

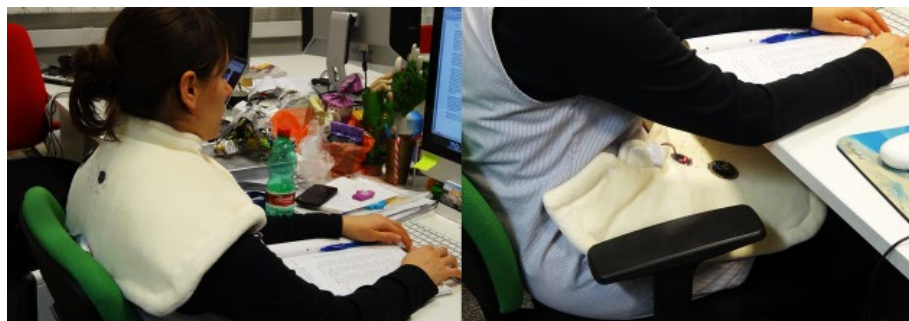


Figure 5.11: Appropriation of the heated shoulder pad.

In the study on personal cooling devices, six participants reported on their appropriation of devices, i.e. using them on different parts of the body, and on aspects of adaptation and flexibility of use. C1, one of the users of the wrist coolers, resorted to the ice packs themselves and used these on the skin without their textile cover, whereas C6 stated that she more often used the wrist coolers to cool down her palms than her wrists. For the ankle cooler, C2 reported that she put it to her forehead and neck, and not only around her ankles. C3 discussed the versatility of the body wrap theoretically but did not actively execute any adaptive measures. For the cooling neck tie participants reported to have also used it on the ears (Figure 5.12), the lap and around the ankles. One participant stated:

“I liked that it is flexible and that I can use it also at other body parts” (C4).

This participant also suggested increasing the flexibility of the tie further by adding a mechanism that would allow the length to vary.



Figure 5.12: Appropriation of the cooling neck tie.

In contrast to the wearable devices, the portable hot water bottle was not predestined to be applied to a specific body location. However, not knowing where to place it confused H2 at first. Eventually, the participant appropriated his jacket to hold the hot water bottle and to provide warmth to his back.

Unlike with any on-body heating or cooling devices, location-related aspects in the use of the fan heater and cooling fan addressed the body-environment relationship at large and the question of provision of heat on an environmental level. Although both participants using the fan heater, H1 and H5, experienced problems with it, they reflected positively on its advantages of being able to heat a larger area of space and the possibility of thus applying it to different parts of the body. Although the effectiveness of the cooling fan in providing thermal comfort was reportedly low, C1 stated to having used the fan daily either placing it on his desk or near his neck. He furthermore noticed that it made him sit more closely to his desk.

Wearability and the Social Environment: Implications of Material, Comfort of Wear, Mobility and Aesthetics of Devices

Matters of wearability, which were brought up by participants in respect to the wearable devices employed in the studies, regarded their materiality, comfort of wear, and addressed aspects of mobility. Aesthetic aspects and unobtrusiveness were addressed in respect to the social environment and matters of fashion.

Three participants reported that the materiality of the devices did impact the wearability and comfort of wear of a device they used. A negative impact was attributed to the material of the heated gloves, which was described as scratchy and which made them uncomfortable to wear (H4). Also, the thickness of the cloth of the heated shoulder pad made H5 feel hot and resulted in him having to take off the device. However, H3 reported positively on the comfort and smoothness of its cover. The cooling neck tie was reportedly not soft to wear (C7).

The comfort of wear was also influenced by the thickness of the heat generation layer and the power supply it required. For example, the heat pad of the heated socks increased the thickness of the socks that had to be worn inside the shoes. Users H1 and H6 stated in consequence that the heated socks were not comfortable to wear in the shoes. Furthermore, the battery packs of the heated socks provided a source of discomfort, as they had to be worn around the lower legs and were felt to be an obstacle and a burden. However, they did provide freedom of movement. Drawbacks were also reported for other forms of power supply. For devices such as the heated gloves and the heated shoulder pad, which were powered externally using USB or mains, the cabling limited the mobility of the wearer and affected their movements negatively. One participant reported:

“cables, too short for me and once I lifted laptop off the table when stretching” (H2).

This and the fact that the controls dragged on the desk and caused an annoying noise led to additional behavioural adjustments on part of participant H2, which included wearing a long-sleeved top, so that he could put the controls into his sleeves as well as the plugging in of the gloves into different devices to increase the range of movement. For the heated shoulder pad H3 reported the cabling as its only downside, because it made her feel desk-bound. Both users of the heated shoulder pad, H3 and H5, suggested a wireless version as a possible improvement. In respect to aesthetic wearability, unobtrusiveness and discreetness were addressed on a personal as well as a social level. One participant stated:

“I like the fact it was personal so the change in temperature didn’t have an impact on other people” (C8).

Also, considerations in respect to the larger social context and implications on self-image took place with participant C7 reflecting on how strange it would be to use the cooling neck tie outdoors. Similarly, C8 commented that she *“would use [the cooling body wrap] outside if it was really hot and it was discreet”* (C8). Discreetness also came up as a suggestion for development. The participant expressed her wish for *“something a bit more discreet, maybe have the choice to control the temperature from a mobile application to ensure discreetness”* (C8).

Furthermore, increasing the aesthetic wearability by developing something aesthetically more appealing was mentioned as a necessary improvement. Participants reflected critically on the appearance of the wearable cooling devices in respect to their clothing style:

“[The wrist cooler] does not match my clothes.” (C6)

“I change my dress according my schedule, not for the cooling neck tie.” (C7)

Individual Preferences and Context of Use

Depending on their usage experience participants expressed preferences between the devices they tested. Both participants, H3 and H5, testing the shoulder pad mentioned it as the device

they liked using the most. The heated gloves (H4) and the fan heater (H1) were each mentioned once in this respect. H4 stated that of the devices she had been given the gloves were the most usable in context but that in general she preferred devices, which covered the back area. Two participants chose a fan heater as the least preferred device because it did not provide enough and direct heat to the body parts that felt cold (H5) or because the one provided by the school was too far away (H3). However, a fan heater was chosen as the device most convenient and useable in the workplace context by its two users, H1 and H5, because it could compensate for local discomforts such as draught from the window and it could heat up a larger area. Although she decided for the shoulder pad as the most usable device in context, H3 stated that a fan heater was in fact the more convenient one to use in general.

In the study on personal cooling devices, the cooling neck tie (C1, C2) and the personal cooling fan (C5, C7) were mentioned by participants as the devices they liked most. However, four participants mentioned that they would find the personal cooling fan most usable and convenient in the context of their work environment in general (C1, C5, C6, C7), because it would not disturb others, it was easy to control, and its orientation could be adjusted. Although, C1 had reported that he could not use his hands properly at work when wearing the wrist coolers, they were mentioned as the most usable and convenient device to use in context by him and C7. The cooling neck tie was only mentioned by C2 in this respect.

C5 and C7 were sceptical of a wearable cooling device after the study and expressed their dislike of having cooling in direct contact with their skin or their preference for more natural cooling in form of a water spray. C2, who had used the ankle cooler, expressed her dislike of putting cooling on her joints. She preferred an unobtrusive device, which would disappear in the environment or could be worn like a garment. C1 and C2 reported that they had a fan turned on in addition to the cooling device given to them.

5.3 Discussion

Reflections on Perceived Thermal Comfort, Use, and Adaptive Strategies

From the feedback of the users on their felt and perceived comfort at different points during a day it emerged that thermal comfort as a perceived experience varies considerably between people and throughout the day. It depends on and is due to various factors, which encompassed the specific local characteristics at a workplace location, as well as situational and physiological characteristics, such as high or low activity, which increased or reduced metabolic rates (Parsons 2002; Schellen et al. 2012). The perceived individual comfort but also device related characteristics influenced the general use and the duration of use of different personal thermal devices, which accordingly varied across devices and participants and ranged from very short to longer periods of use. In general, participants used the devices as intended to bridge moments of

discomfort of short to medium duration. However, in some cases they were used to cover up for the lack of or insufficient space heating or cooling and were used for longer periods.

Participants would in addition choose other forms of behavioural adaptation, such as adding or removing clothing, turning on heating or fans, or opening windows, which was also reported when the devices were available to them. This suggests a cumulative and diverse approach to behavioural adjustments, which has also been encountered in research on the use of different adaptive opportunities in offices (Raja et al. 2001). However, it also was stated that the availability and use of the personal device provided reduced the use of other measures or also initiated further behavioural adjustments. This suggests that solutions for individual thermal comfort are just one means in a set of options for adaptation, which have to fit in the context of use and context of individual comfort.

Perceived Usefulness: Providing Thermal Comfort When Needed, Where Needed, in the Amount Needed and as Long as Needed

Regarding the usefulness of devices, the provision of stable and constant heating and cooling in the amount needed at a certain point in time has been found to be one of the key requirements regarding the effectiveness and efficiency of personal heating and cooling devices. Adjusting heating or cooling within a range of temperature settings would consequently allow the user to respond more effectively to changes in thermal perception according to physical, physiological and psychological processes. Care has to be taken in respect to the design of the control interface, as it can greatly inhibit the ability to control a device effectively.

Furthermore, personal heating and cooling needs to be readily available and its use should not require too much mental and physical effort as well as attention. If too much effort was involved to ensure the availability of heating or cooling, the devices became present-at-hand rather than ready-to hand and their use as well as the focus on the actual work was affected (Heidegger et al. 2010; Dourish 2001). Thermal devices and applications for use in offices should furthermore adhere to principles of calm technology and wearable design and remain in the periphery of users' attention, as suggested by Weiser and Mann (Weiser 1991; Mann 1998). Technological breakdowns as experienced by the users of the fan heater, when the device would unexpectedly stop, or functional breakdowns, such as in case of the ice-pack based cooling devices, which were too cold in the beginning and lost their usefulness when melted, should be avoided, as they monopolise the attention of the user. In contrast, personal devices should strive towards being forgotten by their user.

Increasing Perceived Usefulness through Appropriation and Open Design

To be useful the findings suggest that devices either need to provide a certain versatility and openness in design to allow for adaptation an appropriation or be tailored to parts of the body, which are key to the perception of thermal comfort. As feet are generally perceived as being

colder than other body areas, cold feet are the major source of discomfort in cool environments and strongly impact perceived overall comfort (Arens et al. 2006a; Arens et al. 2006b).

Applying heating to the feet is described as a way to enhance comfort, which is reflected in the positive response of participants to the heated socks. In turn, the head region including head, face and neck is the major source of discomfort in warm environments (Arens et al. 2006a; Arens et al. 2006b). The positive response to the cooling neck tie can be thus explained. But also, the appropriation of devices partly followed this pattern, for example, in the use of different cooling devices on the head, face, or neck, or the heated shoulder pad over the legs. Appropriation of technology is a frequently observed phenomenon in field studies, as users interpret the systems to create their own meanings and adapt its use to suit their specific needs and contexts (Carroll 2004; Sengers & Gaver 2006). It came very naturally to participants to appropriate the devices according to their requirements to achieve thermal comfort in their specific workplace context. The more open the design of the devices was and the less restricted to a specific area of application, the more possibilities of adaptation they afforded and the more variations in use and application were observed. Openness in wearable design primarily regarded aspects of the physical form and fit, as could be seen with the heated shoulder pad and cooling neck tie, whereas portable devices, such as the fans and the hot water bottle, afforded adaptation in use more intrinsically, as they did not predefine the application area per se.

The Desire for Smart Control

In addition, users expressed the wish for a wider range of options of how to control a personal device including remote control but also smart device control, which would allow a device to adjust temperature based on environmental conditions and body temperature. To which extent smart temperature control can provide heating or cooling at the level needed to match individual perceptions and expected states of comfort requires further investigation (Boerstra et al. 2015). Research on the smart thermostat Nest suggests that smart features are not as effective as one might expect, which, however, depends on the ability of the system to correctly classify the user actions it learns from as well as to render its processes legible to the user (Yang & Newman 2013). Unlike smart home applications such as the Nest, which operate on an environmental scale, smart wearable devices face additional challenges in as such as they are close to the body and therefore pose additional questions in respect to how far automation can go for a user to still feel comfortable and in control when changes occurred (Duval et al. 2010).

Thermal Modalities: On-body versus Off-body, Conductive versus Convective Heating and Cooling

Although it was found that users appreciated flexible wearable solutions, overall preferences for solutions, which were not body-bound in nature, were expressed. Scepticism of wearable devices was more widespread for cooling devices, which might be due to the fact that human

thermal perception is in general more sensitive to cooling and that the devices employed during the study were considered too cold (Arens et al. 2006b). However, aspects of acceptance and individual preferences in relation to on-body and off-body applications and uses in respect to personal devices provide an interesting area for further investigation.

Aesthetics and Social Implications

Regarding the design of wearable devices, it was found that aesthetics, materiality and comfort of wear as well as unobtrusiveness have to be taken into account, which corresponds to key design aspects for wearable devices defined by Gemperle et al. (1998) and Rogers et al (2015). Participants showed an awareness of social implications and addressed concerns in respect to the intrusiveness and inconvenience of heating and cooling devices to others. Accordingly, participants expressed a preference for personal devices providing directed thermal output. This corresponds to the findings of a study on adaptation behaviour, which found that adjustments on a personal, local level, such as clothing are preferred by office workers over adjustments on a more global scale (Liu et al. 2014). Aesthetic and physical properties of wearable devices gain relevance once they are perceived as accessories or garments and the boundary to clothing and fashion is crossed and are key to the adoption of wearables (Uotila et al. 2006; Dunne et al. 2014).

Limitations of the power supply affected the duration of use, mobility and flexibility as well as comfort of wear of the devices. However, it is to be expected that with ongoing technological progress, battery sizes will decrease, capacity increase and thus wearability and usability will be improved.

5.4 Summary

This chapter presented the findings of two field studies of personal heating and cooling devices. The bottom up, inductive approach of deploying off-the-shelf personal devices into the wild helped to uncover usability issues of existing devices and raised questions centred on the use, application and design of personal solutions to thermal discomfort in the context of open-plan workplaces. It was found that versatility, availability, control and location of use were key characteristics of more functional and effective devices, as they supported participants' adaptation to changing climatic and physiological conditions and thus helped address changing comfort needs. Although participants responded positively to personal solutions in general, differences were found in responses towards on-body, wearable and off-body, portable solutions, in particular in the cooling case.

Key findings and aspects to consider in the design and development of personal heating and cooling devices can be summarised as follows:

- **control:** the availability of temperature control, either locally and/or remotely and the availability of a range of temperature settings together with the adjustment of temperature levels as needed, manually and/or automated, on a clear, accessible and easy to use interface;
- **functionality and versatility:** designing for application, versatility, flexibility and mobility, which regards the location of use, the technology employed to provide heating or cooling as well as an openness in design affording adaptation and appropriation by the user;
- **usefulness:** the ability to provide heating/cooling when needed (availability), where needed (location), in the amount needed (control), as long as needed (reliability);
- **wearable design:** addressing the aspects of aesthetics, materiality, comfort of wear and the need for unobtrusiveness in the design for comfort;
- **individual preferences:** openness for the preference of individual users for on-body or off-body heating or cooling applications, as well as the preference for different body areas to apply heating or cooling to;
- **context of use:** designing for the context of use on a personal local level as well as taking into account spatial and social implications on a supra-local level;
- **power supply:** considering the usability trade-offs in deciding for battery, mains or USB as power supply in respect to the context of use, duration of use, comfort of wear and mobility.

The identified design requirements are widely reflected in the more broadly formulated challenges and issues in the development of wearable devices and technologies addressed by Gemperle et al. (1998), Rogers et al. (2015), and Benyon (2014). However, as personal wearable or portable devices for thermal comfort are taking over environmental functionalities and are crossing the boundaries between fashion, technology and environment, body, sensations and perceptions, this requires paying more specific attention to the design for comfort, usability and user experience, than more generally defined frameworks cover (Uotila et al. 2006). These findings informed further inquiries in this field and fed into the development of the portable and wearable low- and mid-fidelity prototypes, which will be described in chapters 6 to 8.

Chapter 6

Designing Personal Devices for Thermal Comfort - A Low-Fidelity Study

The requirements for the design of personal portable and wearable devices for heating and cooling obtained from findings of the user studies presented in chapter 5 were intended to provide the basis for the design and development of custom heating and cooling devices to study specific characteristics and questions involved in their use in a shared work environment. A low-fidelity study with low-fidelity paper prototypes and ready-mades was conducted to test suitable paradigms for personal wearable and portable heating and cooling devices and to explore patterns in the interaction with wearable and portable devices further.

Key questions, which this low-fidelity user study addressed, included in which scenario participants would use which functionality and control mode of the prototype, how they would use it and relate to it, for example, if they would use the prototype as a wearable or portable and where they would place it on their body or in the space. Furthermore, the study looked out for any patterns related to use, placement and appropriation, which would provide the focus for further investigation. In addition, a key area of interest included how participants would control the prototype, weighing direct vs. remote control, and what parameters this would involve, such as distance, being within or without reach, comfort of wear, and convenience.

6.1 Methodology

6.1.1 Low-Fidelity Prototype Set

The low-fidelity prototype developed for this study addressed the design requirements laid out in chapter 5 and provided an open design in form of a hybrid, modular system, which allowed to switch between heating and cooling, portable and wearable use, as well as on device and remote control depending on the context of use and personal preference (Figure 6.1). For the user testing the source and app prototypes were built out of white cardboard. The different states of the interface were drawn onto tracing paper, which allowed to overlay interface elements. A paper clip was used to fasten the interface layers onto the cardboard base, which also allowed to

easily add or remove layers. Adding or removing interface layers allowed to change the states of the devices visually, for example, to switch from heating to cooling or indicate a temperature setting.

The prototype set consisted of four elements: a heating/cooling source and on-device control unit, two different distribution elements in form of a fan and a cloth, as well as a smartphone app. The source element and control unit would provide heating and cooling. The state, i.e. whether the device was heating or cooling, on or off, was indicated by a red or blue light in the centre of the device, which at the same time served as an on/off button. The temperature of the control unit could be regulated by turning the indicator layer in respect to a spiral-like scale, which represented the setting from low to high. The control unit interface was developed based on a tangible interaction paradigm, which would allow the user to adjust the setting by turning instead of pressing buttons. As a wearable, the device could potentially to be worn in places where screen-based interaction would not be appropriate due to the device being physically accessible but its interface being out of view. Furthermore, taking aesthetic considerations and the social context into account, in which a screen-based interface might not be suitable, the source could represent a fashion accessory when worn, like a brooch.

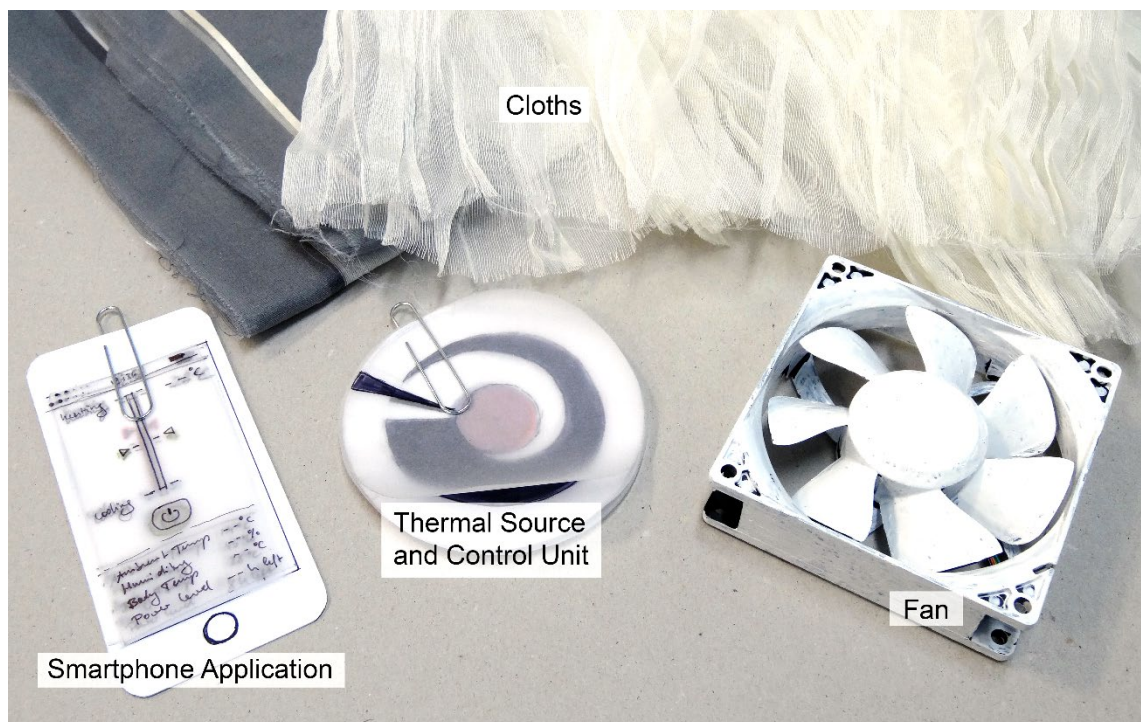


Figure 6.1: Low-fidelity prototype set: smartphone app (left), thermal source and control unit (centre), fan (right), and cloths (top).

To disseminate heating or cooling, the source had to be connected to a distribution element. The participants were given two options to distribute heat or cold: to attach it to a fan (Figure 6.2), which, depending on the setting, would blow hot or cold air once the source was attached, or to attach it to a cloth (Figure 6.3), which would be wearable and would distribute heat or cold

across its surface once the source was connected and switched on. To represent the fan-based device, a ready-made in form of a pc fan was used and to represent the wearable option, simple cloths were provided. The source and control unit could be attached to the back of the fan or anywhere on the cloth using a Velcro strap.

The choice of the two different modalities to provide heating and cooling, convective and conductive, was based on the findings from the study on existing devices (see chapter 5), which uncovered people's preference for devices that provided off-body cooling as opposed to on-body heating. Both prototypes could be controlled directly via the control unit as described above or could alternatively be controlled remotely using a smartphone application. The app allowed to switch the device on or off as well as to adjust the temperature on a linear scale from maximum heating on the top end to maximum cooling on the lower end, with the different states represented by individual layers of tracing paper (Figure 6.4).

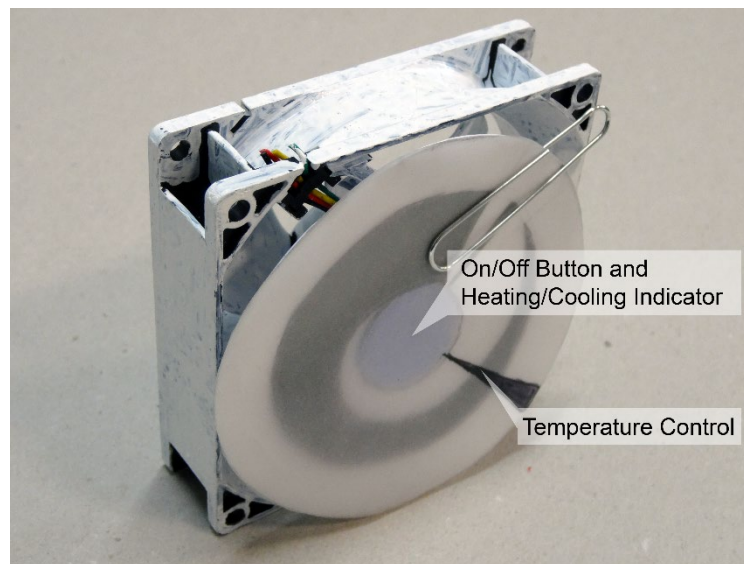


Figure 6.2: Low-fidelity prototype, fan-based application with source and control unit attached.



Figure 6.3: Low-fidelity prototype, wearable application with source and control unit attached.

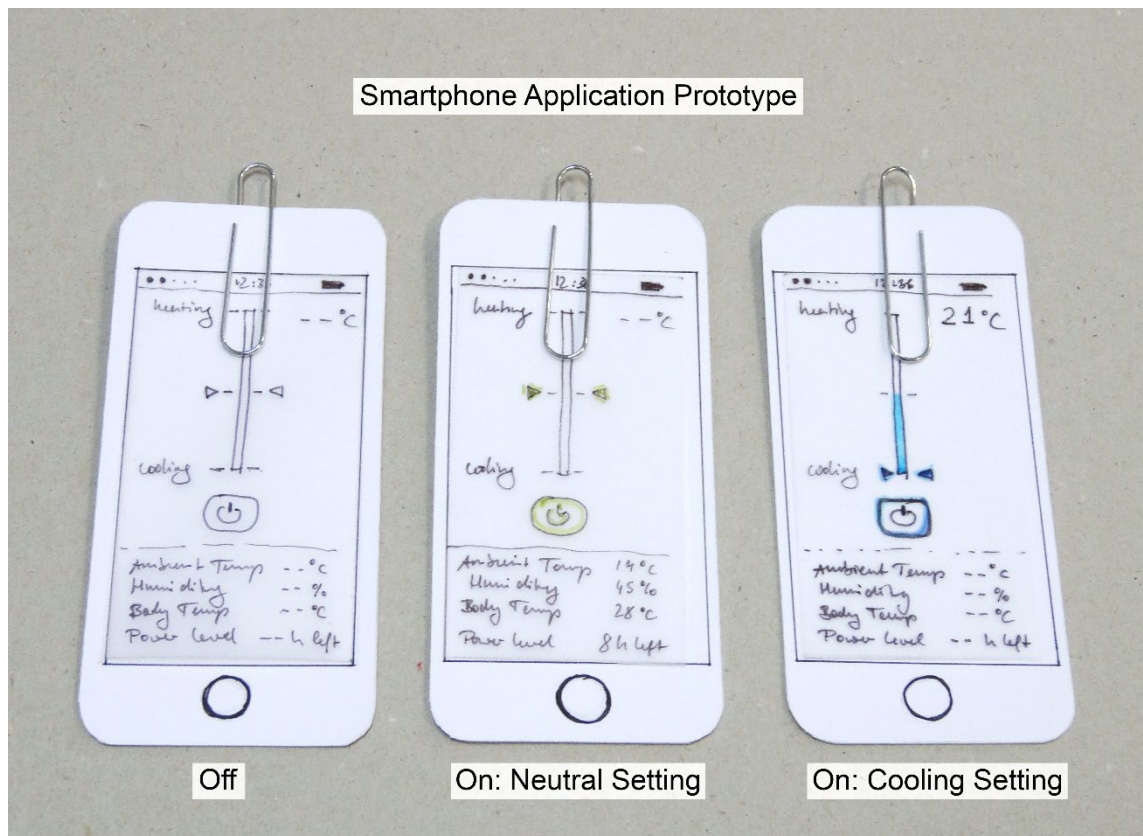


Figure 6.4: Low-fidelity smartphone app with different layers of screens to represent different settings: off (left), on - neutral (centre), cooling (right).

The open design and modular approach of the low-fidelity prototype provided room for interpretation and adaptation, which allowed for a range of different uses and to study a range of aspects related to thermal comfort, the use of personal thermal devices as well as the control of these.

6.1.2 Study Set-Up

Following a user-centred, iterative design process, an early stage low-fidelity prototype was made of paper and ready-made materials, which allowed to outline, test, and evaluate the main functionalities of a personal wearable or portable heating or cooling device as well as validate the requirements obtained from the previous study. The early stage prototype was tested based on a scenario of use, which means that the participants were given an imaginary but nevertheless realistic setting and asked to use the prototype as they imagined they would use it in the given situation. Scenarios of use can be employed in the usability testing of prototypes, as they provide a basis for communication, action, and reflection (Bødker 2000). User testing at this stage also included a participatory design element, which asked participants to address usability and user experience issues of the existing prototype by suggesting and making alterations to the prototype.

The low-fi user testing took place in mid-November 2015 in a lab-based setting (Figure 6.5). First, participants were introduced to the prototype and its basic functionalities. Second, participants were given a scenario, in which they were required to use the prototype as they would use it in the described situation. For the study, three different scenarios were devised. The first scenario described a heating condition, the second featured a heating and cooling, and the third a cooling condition. The scenario descriptions can be found in Appendix C. Participants were taken through a basic scenario and were in addition asked to perform tasks, such as changing the temperature of the device or to react to changing conditions or contexts, such as leaving the office. A session was set to take 30 minutes per participant. Depending on the available time, participants were taken through one or two scenarios of use.

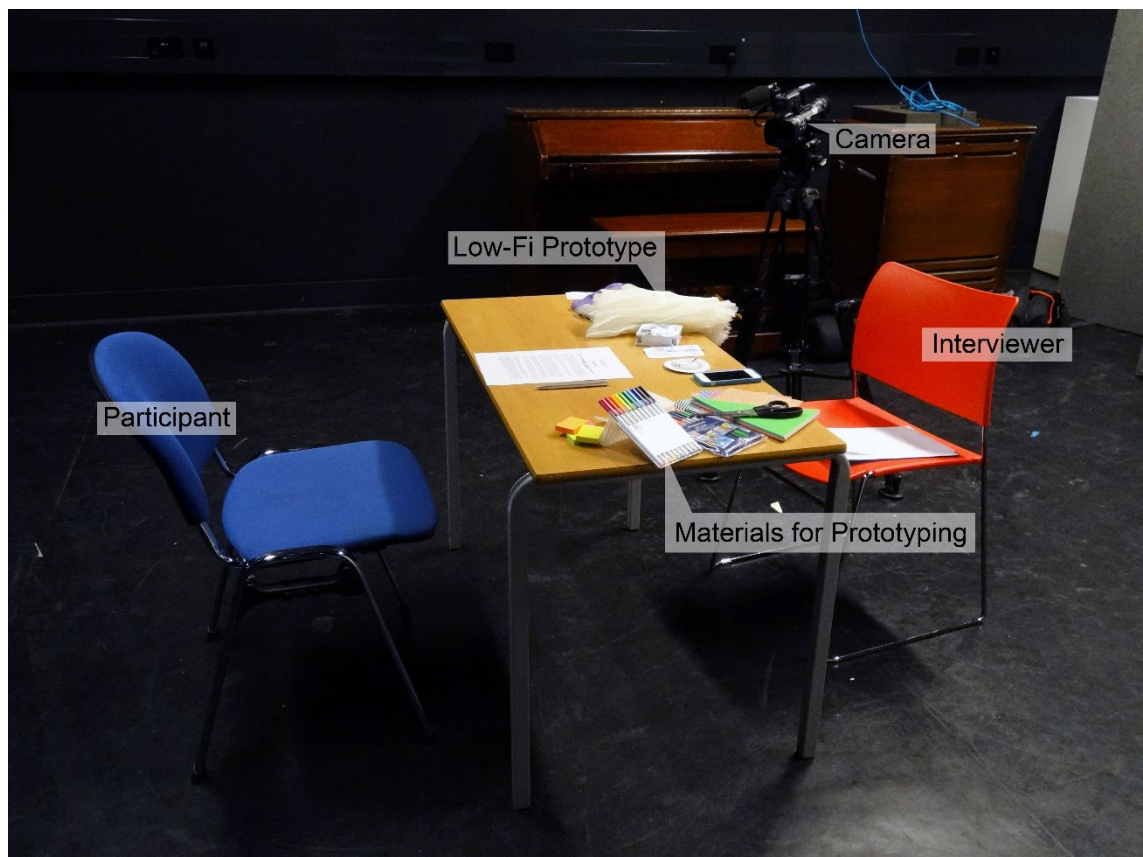


Figure 6.5: Lab set-up.

Lastly, participants were given the opportunity to make changes to the prototype and to suggest alterations based on the scenario and their use of the prototype. Materials, such as paper and post-it notes, pens and scissors were provided. In case the participant suggested alterations, they were asked to explain the functionality and use of these, also highlighting the main differences of use, functionality and perceived effectiveness and comfort in comparison to the original prototype.

The user testing was documented using think-aloud protocols. Participants were asked to verbalise their thoughts and actions while using the prototype and making alterations. The interviewer asked questions in between to facilitate the flow of thoughts and ideas. The sessions

were video recorded and transcribed subsequently to capture thoughts, aims, and respective physical actions of the participants. In addition, participants were asked to fill out a very short questionnaire, which involved questions on what they did when feeling hot or cold in different settings and asked them to provide short written feedback on the perceived challenges of achieving thermal comfort and of using personal devices in their workplace.

6.1.3 Participants

For the usability testing, 15 participants were recruited from the School of Electronic Engineering and Computer Science. All participants were PhD students at the school. The age of participants ranged in between 23 and 42 years of age. The average age of participants was 31.4 years. Of the 15 participants 4 were male and 11 were female. The scenarios alternated between participants. Table 6.1 gives an overview of which scenarios were enacted by which participants. Participants are abbreviated in the following with L1 to L15.

Heating Scenario	Mixed-Use Scenario, Heating and Cooling	Cooling Scenario
L1	L2	L1
L2	L3	L3
L4	L5	L4
L6	L7	L8
L7	L8	L9
L9	L10	L11
L11	L12	L12
L13	L14	L15

Table 6.1: Overview of Participants and Scenarios.

6.2 Results

In the following subsections the results derived from the think-aloud protocols and participatory design exercise are presented. The protocols were analysed using thematic analysis following the steps proposed by Braun and Clarke (2006). However, unlike the inductive thematic analysis performed on the data collected in the evaluation of existing heating and cooling devices (see chapter 5), the analysis of the data collected in this study largely followed a deductive, theoretical approach, as the study was set up to address a series of key questions laid out before. In consequence, the thematic analysis that was performed consisted of a more detailed analysis

of the aspects and establishment of sub themes surrounding the placement of the prototype and the use of its different functionalities and modalities in the three different scenarios looking out for any patterns related to use, placement and appropriation. Furthermore, a more detailed analysis of aspects related to device control and considerations surrounding the choice of using direct or remote control in relationship to prototype modality, context and situation was performed with the goal to establish a better understanding of control-related choices and their meaning. Feedback on the design, usability and usefulness of the low-fidelity prototype as well as suggested alterations and improvements constituted another thematic group. Think-out loud protocol extracts and observations were first coded along the described themes and topics of interest, then gathered and mapped out in form of a mind map. During the ensuing review and refinement process sub themes were developed and established within the overarching themes, which provide the desired insights and focus areas for further investigation. The results of the thematic analysis are presented in the following and subsequently discussed.

6.2.1 Placement and Use of the Prototype Set

The modular approach of the prototype set allowed to study the use, the choice of the modality in respect to convective or conductive heating and cooling, on and off body use, as well as the placement of personal devices for thermal comfort in different scenarios. The following subsections give an overview of the enacted uses of participants in a heating, cooling and mixed-use scenario.

Placement and Use of the Prototypes in the Heating Scenario

In the scenario that was based on a heating situation, three out of the eight participants initially chose to use the prototype based on the fan (L1, L2, L7) and five to use it as a wearable (L4, L6, L9, L11, L13). However, five participants used both modalities in the scenario, either by changing the modality from fan to wearable or vice versa mid-way (L2, L7), by mentioning how they could use the fan as well (L9) or by enacting the scenario for the fan as an afterthought at the end (L6, L13).

The participants using the fan-based personal device for heating placed it on the desk, either at the level of the hands or facing the keyboard to keep the hands warm (L1) or facing towards the upper body (L2, L7). They chose to control it directly on the device by changing the setting using the control unit. Participant L1 mentioned wanting to have it close. Two participants suggested placing it on the floor to heat their feet and legs (L9, L13). Although L13 opted for direct control, she mentioned seeing the sense in having a way to control the device remotely in these cases when the device was out of reach. Whereas participant L1 did not see any need for having a wearable device, as he would not be moving around much, participants L2 and L7 changed mid-way through the scenario to the wearable option to test this, too, as a

fan would make the face dry (L2) and a wearable might be pleasant to use (L7). Participant L4 referred to the cosiness of having something on body for heating as underlying her preference of using the wearable in this scenario:

"And, since it's a cold day I would probably use something like a cloth because I quite like being wrapped up. So, I might wear it as a scarf or something like that. [...] If it's really cold, I would probably have it [the wearable] over my shoulders and stuff. That would be cosy. Yeah." (L4)

"And I'm more likely to use that [the wearable] if it's cold." (L4)

Three out of seven participants used the wearable prototype as a scarf (L4, L11, L13) with the control unit placed either at one of the ends of the scarf (L4, L13), at the side of neck (L13) or the back of the neck (L11). Three participants enacted using it as a blanket to cover the legs (L6, L9) or over the shoulders (L4, L6). One participant imagined having it as a jacket (L7) and another as a belly wrap underneath his clothes (L2). Apart from two participants, who used the app prototype to control the wearable, all other participants used the control unit. Two participants explicitly stated their preference for the on-device control saying that they preferred a direct, tangible control (L13) and liked the physicality of it (L4). The two participants opting for the remote control did so, because the control unit was either not very accessible (L11) or in a place inconvenient to touch, in this case on the shoulder (L6).

Placement and Use of the Prototypes in the Heating and Cooling Scenario

In the mixed-use scenario, which started with a cooling situation and then changed to a heating case, seven out of the eight participants initially decided to use a fan (L2, L3, L5, L7, L8, L10, L12) for cooling, one decided for a wearable solution (L14). However, three participants switched from the fan to the wearable during the scenario, when heating was required (L3, L5) or they would be leaving the office for lunch (L10). All the seven participants using the fan for cooling placed it on the desk in an angle towards and close to their upper body. Participant L8 considered placing it at the back of her chair as well. Four participants mentioned using the on-device control to switch on the cooling (L2, L3, L8, L12) and two participants using the app (L5, L10).

The one participant preferring to use a wearable for cooling down imagined using it as a cardigan with the control unit placed at the lower end of the cardigan (L14). Adapting to the change in the scenario to heating, the two participants switching to a wearable for heating used it around the shoulders (L5) and on the back rest of the chair (L3). Participant L10, who would switch to a wearable when going for lunch, would use it around the lower back and belly when in heating mode and around the shoulders when in cooling mode. Participants L14 and L3 would control the wearable using the control unit on device, whereas L5 would control it remotely using the app.

Placement and Use of the Prototypes in the Cooling Scenario

In the scenario that was based on a situation, which would require cooling, four participants each opted for using a fan-based (L1, L3, L8, L12) and a wearable (L4, L9, L11, L15) solution respectively. One participant changed modalities mid-way (L12), another suggested switching on the fan just for airflow while using the wearable for cooling (L4). Out of the four participants using the fan prototype for cooling, three used it to cool the upper body (L3, L8, L12) and one to cool the face (L1). To target respective position for cooling, L1 mentioned placing the fan prototype on top of a pile of books or the monitor. Two participants would control the fan using the app (L3, L12) and two directly on the device (L1, L8) if the fan was within reach. If the device was out of reach or the person moving around, L8 suggested to use the app instead. Two of the participants opting for a wearable cooling device, mentioned the reasons for deciding against the use of a fan, which included the noise (L11), that it would affect others and might lead to complaints (L11), and that it might blow papers away (L15):

"No, I think kind of overall this seems more appealing, from what I can wear. With the fan I guess it might be ... it depends on how comfortable this clothing was and whether it was restricting but if it was a cloak and my arms were still free I would probably use that. Let's see. I guess if it's cold in my office I would probably put a scarf on so then that would be fine; but equally this is definitely appealing in that it is not just blowing and potentially blowing my paperwork around as a fan can do. "
(L15)

It was also not perceived as effective on a general level (L11). Out of the five participants testing out a wearable cooling device, two used it as a scarf or shawl (L4, L11), two as a coat or cloak around the shoulders (L9, L15) and one as a hat (L12). Most participants controlled the device using the control unit, which was placed on the cloth like a brooch either in the front to fasten the cloak (L9), at its bottom (L15), or close to the shoulder using a scarf (L4). On app control was considered when the control unit was difficult to access because it was hidden in the scarf (L11) or when the control unit was awkward to get to and using the app was considered easier (L15).

6.2.2 Control: Temperature Settings and Adjustments to Changing Conditions

Setting the initial temperature

In respect to how to set the initial temperature of the device two different approaches could be identified: one group of participants started with a conservative setting, and another group of participants started at a high to the maximum setting. Participants starting with a conservative temperature setting in heating mode would set the control unit or app to a low point on the scale (L7, L13) or half-way (L1, L4) to first test and get an understanding of how the device would respond and how warm it would get. Furthermore, they reported that they would evaluate their

initial choice after a while and according to how it felt would adjust it or leave it. Some reported that they would continue making small adjustments to the setting until the temperature fit their needs:

"First of all, since it was my first time using it, I would turn it to half way and see how that goes. I would probably have it at the side, if I'm working at my desk, so that I can feel it when I'm on my keyboard. I would probably give it quite a good time before I... a good twenty minutes before I sort of would think about adjusting it I suppose. See how it feels. Then I would decide it is quite settled." (L1)

"I will start from icicles at the beginning is the starting temperature would be the current temperature in the room. So, I would start turning it towards the increasing temperature just a little bit, because this is my first time. I'm not sure how strong the system is, I mean the heating and then I feel myself again, if it's better I mean if everything was slightly warmer and then if I feel like that I would stop there and if not, I would just turn it bit by bit, bit by bit." (L13)

Participants behaved in a similar way in the cooling mode using a wearable (L4, L9) or the fan (L1, L2, L3, L7, L8, L12). In the cooling mode, participant L8 stated to prefer the fan not to provide a constant air flow to the body but in phases and the temperature to be set to a degree slightly cooler than the ambient temperature (L8). However, in the mixed condition setting the participant indicated preferring it on a constant cooling setting, though at a low setting. Some participants set the source in heating and cooling mode to the maximum (L2, L9, L10) or a very high setting at around the 80% mark in the cooling mode (L3). They reported doing so in the mixed mode scenario to feel cooled down fast (L10):

"I mean in the first process I'm going to make it very cool, like in the lowest temperature, so that I can get a..., so I can feel cooled down." (L10)

Feeling Slightly Chilly

In the heating scenario, participants, who were asked to react to feeling slightly chilly after a while with the device on their initial setting, turned up the temperature setting either on the device (L4, L7, L13) or using the app (L11). Depending on their understanding of the temperature scale, they turned it up by a few percent only (L13) or increased the heat considerably from 35% to 70% (L7). In the cooling scenario, two participants turned down the cooling intensity (L9, L15) of the wearable device and one participant switched off the fan (L8). In the mixed mode scenario, one participant would switch off the fan (L5) if starting to feel chilly and another first test out lowering the cooling using the wearable before switching to heating (L14). Five participants would switch directly from cooling to heating on a low setting (L2, L3, L5, L8, L10). One participant would go for a walk to get the blood circulation going (L12) and prevented this, switch the fan to heating and use it on his legs and feet instead (L12).

Feeling Slightly Hot

Participants, who were asked to react to feeling slightly hot, would in the heating scenario either lower the temperature setting (L9, L13) or switch off the device and use the wearable without heating (L13).

Leaving the Office for Lunch

In the heating scenario, participants using the wearable would continue wearing it and take it along on their break (L4, L6, L13), potentially changing the position on the body from the legs to the shoulders (L6). The participant using the fan would switch it off and leave it in the office (L1). In the cooling case, two participants would switch the wearable off either because it was too bulky to take (L4) or to save energy (L9). Two participants would either take the wearable along in case they needed it (L15) or keep it on and, depending on the outdoor conditions, would continue using it or take it off (L11). The participant using the fan would turn it off but indicated that they might forget to do so (L8). In the mixed mode scenario, four participants would switch off either wearable (L3, L5) or fan (L2, L12) and leave it in the office. One participant would take the fan along because she considered it portable (L7). Another participant would exchange the fan for a wearable and either wear it around the shoulders if continuing to feel hot or wrap it around the lower back if feeling cold instead (L10).

End of the Working Day

At the end of the working day, most participants asked in the heating scenario would switch the personal device off and leave it in the office (L2, L4, L6, L9). However, two participants would take it home (L7, L11), either to have it readily available and because due to its small size, it would allow carrying it in their bag (L7) or they would continue to wear it as they assumed that it could adapt to the changing conditions and continue to keep them warm (L11). In the cooling scenario, two participants would switch the fan off and leave it on their desks (L1, L3), whereas participants would take the wearable along (L15) or keep it on (L12). However, the decision to take it along would depend on the mode of transport, as it was considered convenient to have on the tube but not on a bike (L15). In the mixed mode scenario four participants would leave it in the office and either switch it off (L5, L10, L14) or forget to turn it off (L8).

6.2.3 Fan Prototype: Feedback, Discussion and Suggested Alterations

A personal fan-based device was perceived as useful by participants as it would also create some air flow when it was hot and stuffy (L4). Participants mentioned the benefits of its use during summer, as it could get very hot in their office building (L10). However, participants mentioned many associated problems and disadvantages, which included the noise (L4, L10, L14), that the air flow would affect other people (L4) and that only the parts of the body that were exposed to it would be cooled (L14). Accordingly, one of the participants suggested to

change the position of the fan during use and the area it would warm up (L1). Questions to address in the real-life implementation of a fan-based personal device were raised, which highlighted the power supply, the duration of use and available cooling strength of such a device. The decision between a battery powered or a plugged-in device would have impact on its mobility and range of placement (L1), which would be offset by the duration of use (L12) and the possible cooling strength (L12) it could provide. Furthermore, the size (L10), the appearance and placement (L8) as well as the control of the direction of the air flow (L1) as well as the velocity or flow rate (L2) were considered to play a role in how useful the device would be.

Suggested alterations for the fan prototype and improvements of its functionalities mainly concerned the direction and strength of the airflow but also regarded its placement and possible integration into the work environment. In order to be able to better adjust the angle of the fan and thus to better direct the air flow towards the intended body location, several participants angled the fan during the enactment of a cooling situation (L1, L2, L12). Accordingly, they suggested to add the angle of the air flow as a variable that could be set (L3) or expressed the wish to be able to place it in a way that allowed to direct it towards, for example, the face (L5). To achieve this one participant considered using the environment by placing the fan on top of a pile of books, on the monitor or a desktop computer or the window ledge (L1). To facilitate the directional control of the wind flow one participant proposed a turntable device to change the angle and direction in two degrees of freedom, in the horizontal and the vertical plane (L12). Participant L1 designed a clip or angled bracket, which the fan could be leaned back on or be hung up on (see Figure 6.6). Furthermore, participant L2 and L12 imagined the fan strength to be adjustable, i.e. be able to set different speeds for the air flow. Participant L2 suggested to implement an additional switch on the fan or the controls. Another participant addressed the problem of having limited desk space available and suggested having a fan unit incorporated in the desk instead, like in a dashboard, which would be hidden but at the same time accessible (L8).

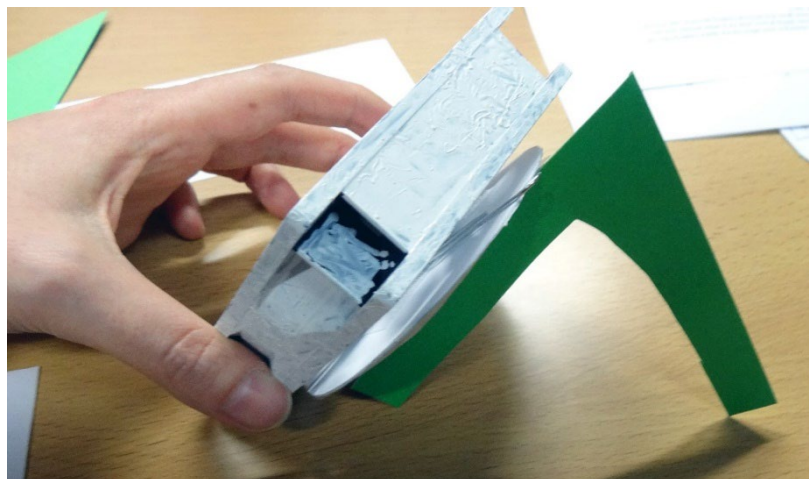


Figure 6.6: Angled bracket designed by participant L1 during the participatory design exercise.

6.2.4 Wearable Prototype: Feedback, Discussion and Suggested Alterations

A personal wearable device was valued for the mobility and place independence, as well as the cosiness of thermal comfort it would provide in a heating scenario (L4). In the cooling scenario the wearable was used by several participants because of its novelty (L4) and to try it out (L9, L12):

"I think because, for the novelty of it, I would like to try this [wearable] with the cooling. But I suspect that it would be nice to have a cool breeze." (L4)

"Although, I forget the clothes until now. So, maybe I could use them too. I mean, it would be really cool if I got a hat. That would be really cool, and then I can put it on, and then it would be like cooling my whole head. So, I can pretend it's a hat, right? [...] So, this is what I would try out too, at least here." (L12)

However, one participant stated that one would not need the same kind of cosiness in cooling as in heating (L4). In general, it was considered useful to provide a way to control one's body temperature at work (L14), which would not affect others or interfere with work activities if designed accordingly (P15). It was considered more inconspicuous, soft, convenient and private as well as portable and easy to carry (L15). These aspects were addressed by participants as follows:

"No, I think kind of overall this seems more appealing, from what I can wear. With the fan I guess it might be ... it depends on how comfortable this clothing was and whether it was restricting but if it was a cloak and my arms were still free I would probably use that. Let's see. I guess if it's cold in my office I would probably put a scarf on so then that would be fine; but equally this is definitely appealing in that it is not just blowing and potentially blowing my paperwork around as a fan can do." (L15)

"I can see other things good about this is that depending on if it's a shared office and if there are other people there, they might get annoyed by the noise of the fan going and throwing things around or you even might get envious whereas this [the wearable] is a little bit more inconspicuous. And sometimes there is tension in offices where some people were like: "don't open the window" or "do open the window" or if there is building noise outside then sometimes that would be [inaudible, 2:14] anyways." (L15)

"There is something quite nice and private and inconspicuous about this cloak, I would say." (L15)

An even temperature distribution across the wearable was considered key to its usefulness (L10). Additional aspects raised in respect to a wearable device regarded its look and feel, washability and smartness. A participant wondered how it would blend in with everyday clothes, as they did not want to attract attention (L10). In consequence, the texture and material (L6, L10) as well as the pattern (L10) should be considered. The material or texture should be comfortable and feel nice against the skin (L6, L10). As a wearable, which would be worn regularly, washability was considered a further concern (L11).

Participant L12 pointed out the generic nature of the wearable device, which could stand theoretically for any possible garment imaginable but would have to be more defined. Accordingly, one participant suggested to look at types of garments, which would be more personal (L4). Although several participants used the cloth according to its form parameter as a scarf, shawl or blanket, other participants imagined specific clothing items or accessories, such as cardigans, hats or wraps. In respect to concrete applications, participant L5 suggested to have a chair cover, which could be wrapped around office chairs and held in place with elastic straps (see Figure 6.7). Ideally it would offer both modalities, a warm heated surface and a cool air flow surrounding the body.



Figure 6.7: Chair cover for thermal comfort suggested by participant L5 during the participatory design exercise.

In respect to the control of a wearable device, one participant suggested a softer control interface using tactile buttons, which could be integrated in a scarf alongside the thermal source (L11) and provide suggested built-in control (L14). She furthermore suggested simplifying the control on the device and limiting it to an on/off button, which could be easily activated and two buttons for respectively increasing and decreasing temperature (Figure 6.8). Furthermore, aspects of smart control were discussed in respect to the ability of the device to adapt to changes in environmental and physiological contexts (L11), which included the adjustment of the temperature and the transition between heating and cooling mode, and in respect to the need of

addressing forgetfulness in switching off devices automatically (L8, L11) or putting them on stand-by mode, which would also allow them to be activated when put on (L14).



Figure 6.8: Tactile buttons suggested by participant L11 during the participatory design exercise for on-device control of a wearable prototype.

6.2.5 On-Device Control Unit: Feedback, Discussion and Suggested Alterations

The thermal source and control unit was well received by participants, who found it easy (L7), satisfying and intuitive to use (L14) and liked its design and form (L7) as well as its physicality (L4) and the direct, tangible interaction and feedback it provided (L13). Participants commented positively on its ease-of-use in respect to controlling the temperature but also in attaching it to different outlets (L7). The continuous scale it provided was mentioned as more intuitive to use (L14), as it allowed to feel the temperature with the body rather than to cognitively assess the setting using numbers. General suggestions for improvement of the control unit regard its form, size, weight, integration and appearance. Two participants suggested to make the control unit smaller, light-weight and softer for a wearable application (L11, L15) with one participant suggesting tactile buttons (L11, see Figure 6.8), which would preferably allow to integrate the control in the wearable device (L11, L14). In this respect it also was discussed that the unit

needed to be weather-proof and durable (L14, L15) but stylish at the same time (L14), comparable to an accessory.

Suggested alterations and improvements for the control unit primarily regarded the design of the control interface and interaction. Two participants suggested to use a continuous scale for heating and cooling (L2, L11), and thus to have the same mapping for the control unit as for the app and to remove one unnecessary click (L2). The suggested continuous scales participants provided during the participatory design exercise can be seen in Figure 6.9. However, participant L15 discussed a continuous scale critically suggesting that it might be good to keep the modes separate in case the direction and setting of change was not clear and might provide unintended discomfort.

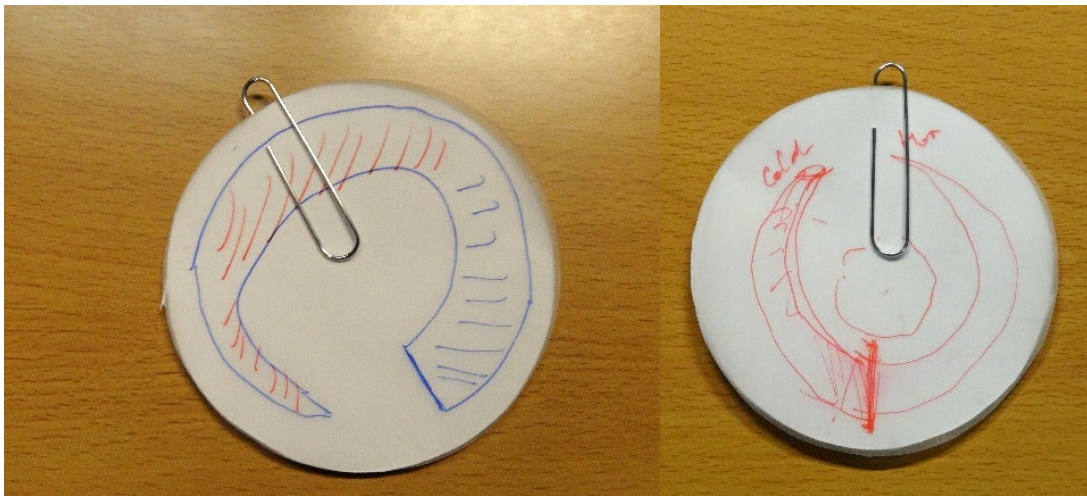


Figure 6.9: Continuous temperature scale for the control unit provided by participants L2 (left) and L11 (right).

Further interface alterations, which were suggested, include the display of the chosen setting with dots of light along the rim of the unit and instead of the colour red to use white to indicate heating and blue for cooling (L9, Figure 6.10). Another participant suggested that the light in the centre could respond to the interaction of a user and light up in blue if temperature was decreased (L13). Also, participants proposed displaying a suggested temperature range to the user to give an indication of a meaningful temperature choice based on the ambient temperature (L14). To provide information on the responsiveness of the system, participants suggested to have some form of indicator to provide information on the current state and temperature of the device in relation to the desired state (L14) or an indication of where the ambient temperature and a preferred temperature setting (L9, L11) could be found on the scale (Figure 6.11). This was proposed as a counter measure to overcome the impulse to start with a maximum temperature setting:

“If, for example, there would be some indication of, I don’t know, if it could suggest to me a temperature range, that would be even better. Because I know that the compulsion for people is when they’re really, really hot, they just whack the cool all the way up to 100%, which, I mean, thermostats don’t work like that, and we all know

this, but we have that mental desire to do that. Or you come in and you're freezing and you're, 'Oh my god, turn the heat up to 45', it's ridiculous, but we do that. And so, if it could suggest a temperature so I didn't have to take my best guess. If it could suggest a range or something like that, then that would be really useful." (L14)



Figure 6.10: Display of the chosen setting using lights suggested by participant L9 during the participatory design exercise.

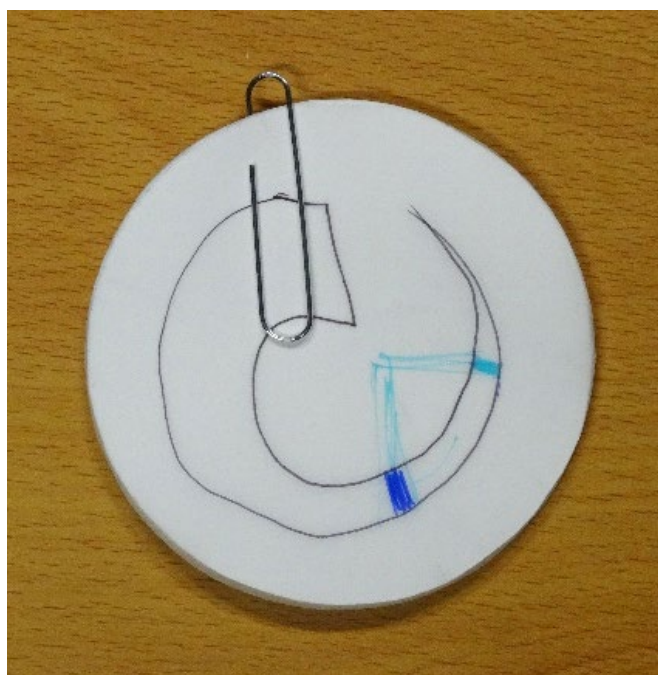


Figure 6.11: Smart device proposed ideal temperature range (angle) and display of current state (light blue bar) and chosen setting (dark blue bar) suggested by participant L14 during the participatory design exercise. The current state indicator would travel towards the chosen setting while the temperature of the device was changing.

6.2.6 Smartphone Application for Remote Control: Feedback, Discussion and Suggested Alterations

The perceived advantage of the smartphone application was that it provided information on the ambient and device temperature and allowed a more precise control of the device (L9, L10). However, the mental and cognitive effort involved in having concrete numbers was critically discussed by participants, as it meant a different kind of awareness and understanding of the temperature (L15), which was more based on mental models than bodily perception (L14). The use of a smartphone application was considered depending on the context and conditions, if the device was within reach (L1, L13) and where the on-device control was placed, i.e. if it was accessible and did not feel awkward to use (L6, L15).

Suggested improvements of the smartphone application regarded additions to the interface and control options or the information display as well as additional functionalities. One participant suggested to display the ambient temperature on the temperature scale depicted in the app and to add a separate screen to show the performance of the device (L9). One participant suggested to align the mappings between control unit and app (L2), whereas another suggested to divide functionality between on-device control and smartphone application (L11). Participant L11 suggested to complement the on-device control of a wearable with tactile buttons for on/off and temperature increase and decrease with a more elaborate smartphone application, which would provide general information and allow to pre-set a preferred temperature. Switching on the wearable either on the device or via the app would automatically set it to the preferred temperature. The first app screen would only consist of a display of the pre-set and an on/off button. Temperature and device information as well as a screen, which allows to change the pre-set, would be accessible from the first screen. The suggested control ecosystem can be seen in Figure 6.13. In respect to additional functionalities, one participant suggested to add an alarm to the application, which would go off when the device was still on but device and phone out of reach of each other or the initiation of an automatic device switch off (L8).



Figure 6.12: Suggested alteration of controls designed by participant L11 during the participatory design exercise: preferred temperature pre-set screen with additional information (left), continuous fan control (centre), and tactile buttons for controlling the wearable (right).

In addition to feedback on the proposed systems for on-device and remote control, participants suggested to have integrated controls, for example, into the table top (L4) or the chair (L8) that would be more accessible than an app or a control on the device, which might be out of reach.

6.3 Discussion

This section reflects on the findings obtained in the low-fidelity user study in respect to thermal comfort, the use of personal devices and control. Furthermore, the limitations and shortcomings of the approach will be critically assessed. Finally, questions for further research will be raised and directions for further investigation will be provided.

6.3.1 Reflections on the Use of Personal Thermal Devices in different Scenarios

The enacted use of the prototypes based on two different modalities, wearable and fan-based, in the different scenarios uncovered a series of patterns, which will be discussed in the following.

These concern preferences in choosing a specific modality for heating or cooling, perceived portability and usefulness, as well as the extension of the body-environment.

On-Body Heating and Off-Body Cooling

The use of the prototypes in the different scenarios showed an overall preference for on-body, conductive heating and off-body, convective cooling. A reason for participants to not opt for a wearable cooling solution was a lack of experience and familiarity with those kinds of devices. Participants, who instead chose to use a wearable prototype for cooling in the cooling scenario, mentioned the aspect of novelty as a reason for doing so. The preference for the use of a personal fan-based device for cooling can be explained with the familiarity of the modality and the positive effect of air flow on perceived thermal comfort. Generating air flow either by opening windows or the use of fans is also a method commonly employed in naturally ventilated offices (Stazi et al. 2017). Air flow contributes positively to people's perceived thermal comfort and perceived air quality in warm environments and helps to reduce the indoor temperature during the summer months (Zhang et al. 2007; Stazi et al. 2017). Conductive cooling on the other hand is less commonly employed by occupants in office environments because of the lack of suitable options.

Available commercial options, such as the ice-pack based wearables employed during the study described in chapter 5, have mainly been developed for outdoor or short-term uses and are less user friendly and easy-to-use in an office context, as the cooling effect is not readily available and the strength of cooling not controllable. New wearable electronic cooling devices, such as the Embr Wave (Embr Labs 2018), however, can bring conductive cooling technology into everyday life and make it available in these contexts in near future.

The preference of using a wearable device for heating was explained in relation to the feeling of cosiness and the habit of using elements of clothing to overcome cold discomfort. The adjustment of clothing levels is the most common form of behavioural adaptation and the first choice when dealing with thermal discomfort in cold environments and also in hot environments where applicable due to office clothing regulations and norms (Liu et al. 2014; Chappells & Shove 2005). The preference for adjustments on a personal level are based on considerations on interpersonal scale, such as the impact of measures taken on colleagues (Leaman & Bordass 2005; Shahzad et al. 2017; O'Brien & Gunay 2014). Respective considerations were also observed in this low-fidelity study. The choice for wearable was frequently explained by citing the disadvantages of a fan-based solution, such as the noise and impact on the surrounding environment and colleagues. Wearable specific trade-offs considered included comfort of wear, freedom of movement and interference with the work in context. A preference could also be detected in taking a wearable along to a lunch break or on a commute as opposed to taking a fan-based device along, as the wearable was considered the more portable and viable option.

The Extended Body: Appropriating the Close Personal Environment

Whereas a wearable solution was also considered a more private one, the use of the fan extended personal thermal comfort to incorporate the close personal environment. Participants preferred to keep it within reach on the desk taking advantage of the environment in finding a place, which would provide a suitable angle or direction. Suggestions to incorporate vents into the desk-top or a chair cover for heating or cooling further extends the provision of thermal comfort to the close personal environment, a functionality and form, which relates to existing or proposed PEC systems presented in chapter 2. The suggestion of participants to provide desktop control rather than on-device or app control is supported by findings that the more effort it takes to execute control, the less likely a control action becomes (O'Brien & Gunay 2014).

6.3.2 Reflections on Device Control and Control Related Behaviour and Cognition

In addition to different aspects uncovered from the use of the devices, the choice of control mode, on-device or remote, and its reasoning as well as cognitive and behavioural aspects related to temperature control could be observed and provided insights.

Getting to Know the Device: Approaches to Temperature Control

As described in the results section, two general approaches to adjusting the temperature of the device could be observed: starting with a conservative temperature setting and starting at the maximum. Participants starting at a low temperature setting or from the midpoint mainly referred to getting to know the device as their reason for doing so and stated that they would check back and evaluate if the setting is suitable. In this they followed an exploratory trial and error approach to bridge between their expectations and needs and the mapping of the device. Participants, who started at a maximum setting either for heating or for cooling reasoned their approach with a desire to cool down or heat up quickly. Occupants acting on impulses to reduce thermal discomfort when it occurs with quick and simple solutions has been observed in the literature on behavioural adaptation in buildings and has been critically discussed in respect to building energy use (Heerwagen & Diamond 1992). However, regarding a personal thermal device respective behaviour can potentially lead to and cause thermal stress especially when the device is worn on the body. Participants discussed these issues critically and addressed the challenges in the design of wearable devices. For example, participant L14 reflected critically on the inclination to start at the maximum temperature and suggested an interface intervention to help overcome the impulse.

Two additional aspects to take into account are the calibration of the control steps and the response rate. The calibration regards the granularity and sensitivity of the scale and how changes in the settings are mapped into differences in degrees. The response rate regards the

speed of the response. In interaction design, generally the response of interface changes is considered having to be immediate without a perceptible time lag. However, when dealing with a body-worn thermal device, in which changes in temperature could potentially cause considerable discomfort when the granularity is not known and when it is accidentally set to a temperature outside the person's comfort zone, the response rate could be set in a way that allows the user to intervene while the change is happening. As such, a slow response rate, which can be later adjusted by the user in the settings, could support the initial learning process when getting to know a thermal device, reduce the risk of discomfort and increase usability of a thermal device over the lifecycle of the user-device relationship once familiarity is established.

Accessibility, Social Acceptability and Cognition: Parameters affecting the Preference of Smartphone and On-Device Control

The results of this study showed that the choice between smartphone and on-device control was majorly dependent on the perceived accessibility of the control, whether the device was within or out of reach, social acceptability, whether interaction with the control on the body was considered socially acceptable, inconspicuous and not perceived as awkward by the wearer, and based on a preference for either cognitive, information-driven versus sensory, body-driven control. In respect to accessibility, on-device use was preferred for the fan when within reach in the close personal environment, whereas to control it remotely was considered the preferred option when the fan was out of reach.

Accessibility was also the parameter underlying the choice of manual versus remote control or vice versa in the case of a personal wearable device. However, the choice of control mode for a wearable device was further dependent on the placement of on-device control and the social acceptability of the specific on-body interaction resulting from it. Social perceptions of interaction with wearable technology on the body were studied by Profita et al. (2013), who found that the acceptance and perception of on-body interaction with a wearable control of others is dependent on body location and gender, but is also culture dependent. In consequence, the placement of control interfaces and the interaction designed around it should be inconspicuous and not embarrassing to the wearer, aspects, which were frequently brought up in the study.

An aspect for discussion on the other hand were differing preferences of participants between sensory and cognitive control, which manifested themselves in the choice of the smartphone app or the control unit for interaction. Participants opting for the app interface argued that it provided additional information and allowed a more precise control of the temperature in degrees than the analogue control unit interface. In contrast other participants found the control unit interface with its temperature scale more intuitive to use and more supportive of perceived comfort and a sensory experience.

Smart Control: Catering for Human Fallibility and Dynamic Environments

Smart control was mentioned by several participants as a functionality they would wish for and ranked among the suggested improvements, in specific for a thermal wearable device. Aspects considered by participants regarded device functionality in the transition between different thermal environments and addressing evolving needs in transient environments, to provide an answer to matters of human forgetfulness and to improve the usability of the device through pre-sets. Participants expressed a wish for an adaptive device control, which would adjust the temperature and modality of the device based on ambient and body temperature. Furthermore, it would be learning about the wearer's preferences and adjust itself accordingly in relationship to the ambient temperature. Smart adaptive temperature control could also provide a solution to the inclination of manually setting the device to the maximum or choosing an uncomfortable setting as described earlier and could also address concerns such as energy consumption mentioned by participants. It could be based on existing applications in the area, for example, on smart thermostats, such as the Nest or Honeywell. However, in user studies it was found that the supposedly smart devices fail to understand user intentions in context unless extensive training is provided by the users by giving regular feedback (Yang & Newman 2013). This would contradict the prerequisite of wearable technology to be 'unmonopolizing' and receding into the background of attention (Mann 2001).

An aspect addressed by several participants was the risk of forgetting to switch off the device after use, which was perceived as highly likely. In consequence, participants suggested different smart functionalities to cater for this, including for the device to automatically switch-off or go on stand-by. Alternatively, a smartphone alarm was considered, when device and phone would lose connection. As one of the aims of wearable devices is to recede from the centre of attention of their wearers, the fallibility of the wearer to forget to switch off the device is an important aspect, which needs to be addressed in the design of such a system. Forgetting to switch off devices is a well-known problem in appliance design, which has been overcome with the introduction of standby modes. However, the application of standby creates a problem of its own with standby use amounting to up to 11% of yearly energy consumption in homes (Meier 2005).

6.3.3 General Feedback on the Study Design

In general, the response of participants to the study design was positive. Participants could identify with the scenarios provided and stated having experienced similar situations in real life. They also commented positively on the choice the prototype set provided in respect to getting hot and cold by either using convective or conductive heating and cooling and the two different control interfaces and modalities provided, which helped to address different contextual scenarios of use.

However, participants also pointed out problems inherent in the prototype design and underlying assumptions as well as the study setting. For example, participant L11 stated that wearable and fan were completely different scenarios in themselves and could not be combined as suggested, as a control unit would have to have different inherent characteristics for each, for example, be flexible and small for a wearable device. Furthermore, the setting of the study was considered being too abstract, as it did not provide the required context, which in this case meant an ambient temperature that matched the scenario conditions. Lab-based studies have been criticised for the lack of richness of a real-world context and thus to not provide valid insights on the actual use in context (van der Bijl-Brouwer & Dorst 2017). However, scenario-based user testing has been shown to have its merits in many analysis, design and evaluation settings when the focus is on exploring ‘what-if’ scenarios and tapping into participants’ imagination to gain insights and uncover unforeseen challenges or solutions to novel questions (Rosson & Carroll 2002).

6.4 Summary

The scenario-based study of low fidelity prototypes allowed to uncover additional aspects to be considered in the design of personal thermal devices, which constitute pathways to the further investigation of people’s relation, use, control and interaction with wearable and portable devices for thermal comfort in the scope of this thesis. Directions for further investigation and consideration include human behavioural and cognitive aspects in relation to thermal comfort and device use:

- **Comfort Modalities:** considering preferences for off-body convective cooling and on-body conductive heating;
- **The Extended Body:** taking into account the perception of self and its extension to incorporate the close personal environment;

Furthermore, the following in aspects regarding the modalities of device control and the implication of behaviour and cognition on temperature perception and device interaction need to be addressed and considered:

- **Accessibility:** the contextual boundaries and implications and impact of modality on the choice and requirements for remote and on-device control and specifications;
- **Social Acceptability:** the placement of control on wearable devices and implications of the perception of interaction;
- **Adaptive Response Rates:** supporting the learning process in getting to know a device and the wearer-device relationship over its life-cycle;
- **Cognitive versus Sensory Control:** acknowledging the impact and role of information in control interfaces on perceived thermal comfort;

- **Smart Control:** supporting thermal comfort in transient conditions and addressing human failure;

In the scope of further development, the following topics, which emerged both out of the study described in chapter 5 and the findings of this study, were selected for further investigation: the role of affordances in the appropriation of personal conductive heating devices, which will be described in chapter 7, and considerations and attitudes towards adaptive and manual control of personal wearable cooling devices, which forms the basis for the investigation described in chapter 8.

Chapter 7

Studying the Achievement of Thermal Comfort through Affordances and Appropriation of Personal Heating Devices

This chapter presents the development of a portable and a wearable personal heating prototype to assist the closer investigation of the role of affordances on appropriation of devices in context as well as the achievement of thermal comfort through adaptation of use. As the study on the usability of existing heating devices uncovered (see chapter 5), the ability of a device to provide heat to the right body location to ease the feeling of thermal discomfort or provide thermal comfort had a positive impact on the reported satisfaction with a device and increased perceived thermal comfort. Furthermore, it was found that the degree of openness in the affordances and the versatility of the design underlay the ease of appropriation with which a device could be adapted to an individual's needs in this respect. Therefore, this study looks in closer detail at how individuals achieve thermal comfort through the use and appropriation of two personal heating devices, which design-related aspects and affordances support and influence acts of appropriation and adaptation by the user, to what effect and how these are perceived.

7.1 Methodology

Based on the results of the user study on existing thermal devices, which found that artefacts with a design that is open to interpretation and flexible, less prescriptive in form and consists of a larger surface area, such as the heated shoulder pad, provided versatility and was successful with participants, as well as following up on the low-fi user study, in which a nondescript cloth was used as a prototype, this study opted for a similar open prototype design and compared it to a prototype, which was more limited in respect to the actual use applications it afforded due to its more compact form. As stated in chapter 2, affordances refer to the possible uses or possibilities of action of a device, which can be perceived and relational or actual (Kaptelinin 2016; Norman 1998). In particular, the design of the prototypes was based on aim of supporting interpretation through openness of use (Sengers & Gaver 2006) or what has been called

‘definition of use through design’ (Redström 2008). This design approach allows users to interpret the meaning of the artefact and its usefulness through their use and a designer or researcher to explore the underlying opportunities in a design (Sengers & Gaver 2006; Redström 2008).

7.1.1 Prototypes

For the study, two heating prototypes were developed with different inherent affordances: a scarf-like device as a wearable and a cushion-like device as a portable. Both prototypes afforded on-body, conductive heating using a resistive heating element. Introducing the constraint of contact heat limited the application of the prototype to the body and the close personal environment and thus limited the context of use for better comparability. However, the prototypes differed in the size of the heating area and in consequence their battery life.

Wearable Prototype

The wearable prototype was constructed out of a 110cm by 200cm scarf, which was folded in half to contain the heating element. The scarf was made from a soft, half cotton half viscose fabric. A carbon fibre tape was employed as a resistive heating element and arranged and sewed onto the fabric as depicted in Figure 7.1. Sewing hem tape was used as an interface between the carbon fibre tape and the fabric and ironed on. Power and ground connections were placed at the bends of the carbon fibre tape in four places forming a parallel circuit. Silver glue was used to improve the connections between the carbon fibre tape and the cabling. Super flexible cables were used for the prototypes used during the main study to improve the feel and the bending capabilities of the prototype. The connections were insulated using insulation tape.

The electronic circuit was thus constructed that the heating circuit could run on a 12V/2A battery. The circuit was rated at 24W with 2A at 12V on full power. Participants could adjust the heating strength using a dimmer switch. The lithium battery provided 4800 mAh, which allowed to run the prototype on full power for 2 hours without charging. A sensing circuit was added to the finished prototype to monitor the device temperature when in use. The sensing circuit consisted of a LilyPad temperature sensor facing towards the carbon fibre tape, an XBee Series 1, which allowed to send the temperature data to the base station, and of a battery pad, which allowed to power as well as switch on and off the circuit using a 3.7V/2500 mAh Lithium battery. The prototype including sensing circuit, dimmer switch, and battery is depicted in Figure 7.2.

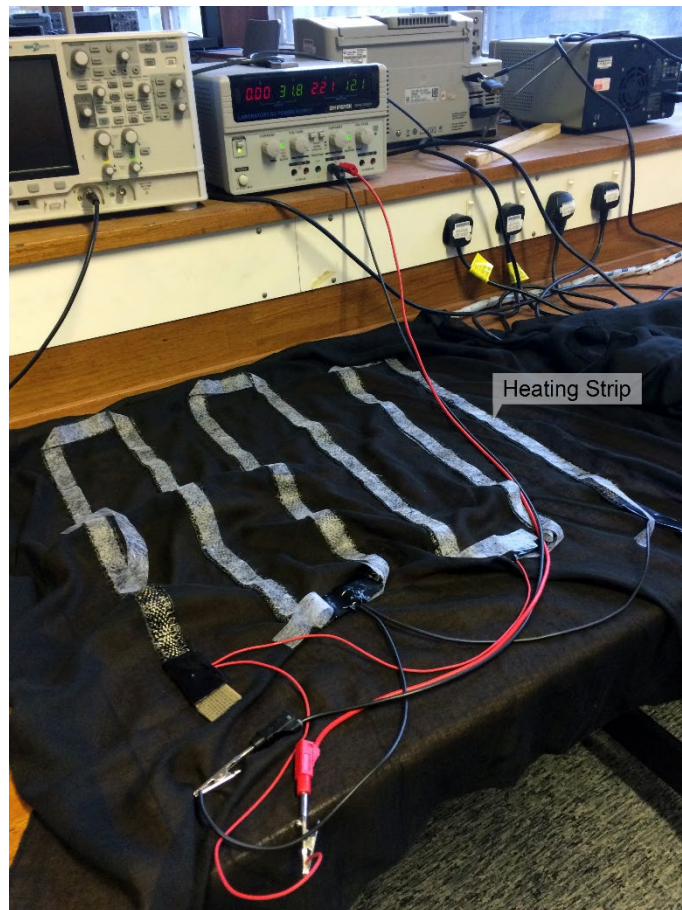


Figure 7.1: Arrangement of the heating element, construction, and testing of the wearable prototype.



Figure 7.2: Arrangement of the wearable prototype including sensing circuit.

Portable Prototype

The portable prototype was constructed out of a 15cm by 40cm neck roll and an all-cotton cover. The heating circuit was sown onto the inside of the cover and consisted of a 100cm long piece of carbon fibre tape (see Figure 7.3). The circuit was constructed in a similar way as described for the wearable prototype, i.e. using hemming web tape as interface and silver glue to improve conductivity between carbon fibre and cabling. For the pilot prototype, however, the heating circuit was covered in insulation tape. As this made the cover less flexible and consequently had an impact on the material feel of the prototype, this was changed for the prototypes used during the main study. Also, the pilot prototype consisted of a parallel circuit, which was constructed as described for the wearable prototype. However, this increased the power rating of the prototype. Also, it meant that the portable prototype would get warmer than the wearable one. Therefore, the circuit had to be amended for the prototypes used during the main study, during which it consisted of a simple, single loop circuit at a length of 100cm. The main study prototype was rated at 12W/1A on full power. The portable prototype used the same dimmer switch as well as run on the same battery as the wearable prototype. The portable prototype could run for 4 hours on the highest setting without charging.

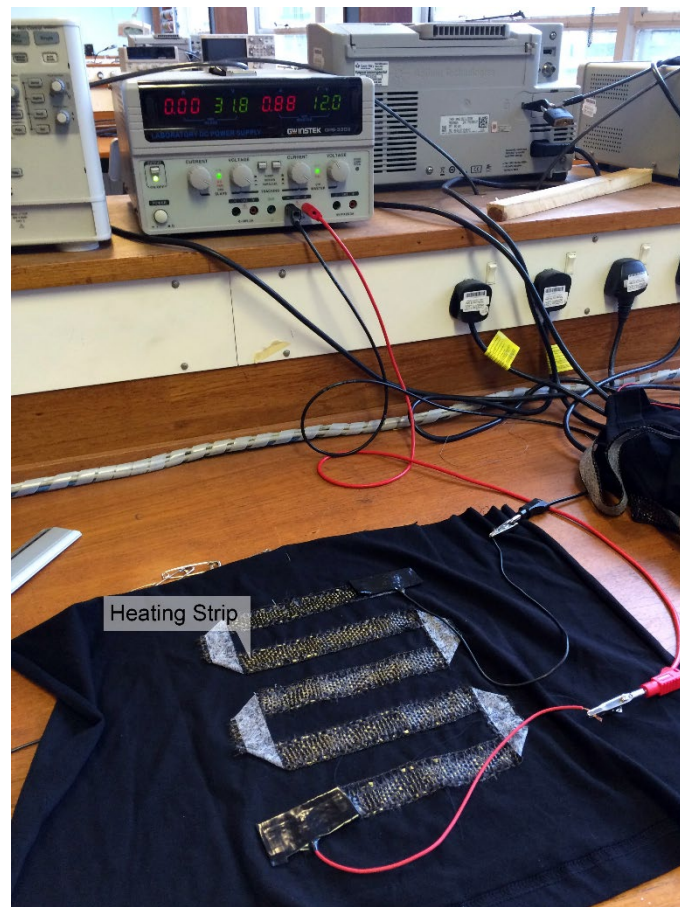


Figure 7.3: Arrangement of the heating element, construction, and testing of the portable prototype.

The portable prototype was also equipped with a sensing circuit. It consisted of the same elements as the sensing circuit on the wearable prototype: a LilyPad temperature sensor, a

battery pad and a lithium battery, as well as an XBee Series 1 for data transmission. The full arrangement of the portable prototype including the sensing circuit, the dimmer switch, and the battery pack can be seen in Figure 7.4.



Figure 7.4: Final arrangement of the portable prototype including sensing circuit.

7.1.2 Study Set-Up

The study was set up in a similar fashion as the study looking at the usability of existing devices described in chapter 5. It also consisted of two parts: the assessment of thermal and environmental comfort and the testing of the prototypes. First, the overall conditions and the general comfort of participants in their workplace was assessed using a long-term comfort questionnaire, which also looked at the experiences of participants with and their perception of comfort in their workplace environment as well as their thermal background. The questionnaire featured a short version of general comfort assessments looking at different IEQ parameters but mainly focused on aspects of thermal comfort and environmental control. This was combined with questions on participants' thermal background, i.e. whether they easily feel too cold or too warm, as well as behavioural adjustments they usually performed to increase personal thermal comfort in their workplace.

During the second part of the study, the actual thermal comfort of participants at their workplace was assessed using the sensor nodes developed for the usability study on off-the-shelf cooling devices. The sensor nodes were again installed on the desk and stayed installed throughout the study. In addition, participants were asked to fill out a right-now questionnaire reporting on their perceived thermal comfort up to four times a day on each day of the study period (chapter 3.2). This study used the amended questionnaire (see chapter 3.3.1.), which was

based on an example featured in Nicol et al (2012) and was extended to contain a comment section for participants to record any changes in perception, adaptive behaviours, or changes of comfort or discomfort they became aware of in relation to environmental temperature, other people's actions or devices, any personal devices they used or their use of them.

The main part of the study consisted in total of three episodes per participant, during which they were given the prototypes described in chapter 7.1.1. to use according to their liking to improve their felt comfort. First, each prototype was given to a participant to use for two working days respectively. Then both prototypes were made available to participants for another two working days, during which they could choose freely which prototype they wanted to use. This no-choice/choice approach was implemented to find out which of the two personal heating prototypes users preferred and why (Siegler & Lemaire 1997; Walsh & Anderson 2009; Brumby et al. 2011).

At the beginning of each test period the prototypes were explained to the participants and they were shown how to use them. Participants were asked to switch on the sensing circuit when starting to use the device and to switch it off after use to record the duration of use. In addition, they were given health and safety instructions, which included to not use the device if it was wet or if they felt uncomfortable using it and to report any issues to the researcher. At the end of each individual test period for a device, participants were asked to evaluate the prototype they were using and to reflect on their use of and satisfaction with the device by filling out an evaluation questionnaire.

At the end of the testing, a brief semi-structured interview was conducted. In the structured part, all participants were asked how they used the prototypes during the individual episodes and to show where and how they used them. In addition, they were asked which prototype they used during the days they had both available and why. Furthermore, they were asked if they had wished to be able to take them along and if they would have used both at the same time if they could have. In addition, each to these scripted questions, participants were asked individual questions based on the answers previously obtained from the prototype evaluation questionnaires, mainly to clarify some of the responses or obtain further information. The interviews were video or audio recorded and subsequently transcribed.

7.1.3 Participants

The data collection for the evaluation of personal, wearable or portable heating prototypes took place in March/April 2016 over the course of six weeks. Participants were recruited among PhD students at the School of Electronic Engineering and Computer Science at Queen Mary, University of London. Participants were recruited by email. Out of the 11 participants recruited, 6 participants were female and 5 were male. The age of participants ranged from 24 to 42 years of age. The average age of participants was 29 years. All participants worked in shared offices

either in the Electronic Engineering or the Computer Science building on campus. The order of testing the wearable and portable prototypes was alternated between participants so that five participants started with the wearable prototype and six participants started with the portable prototype (Table 7.1). The contributions of individual participants are anonymised and attributed in the text by the abbreviations A1 to A11.

Participant	Building	Device 1	Device 2
A1	CS	Portable Prototype	Wearable Prototype
A2	Eng	Wearable Prototype	Portable Prototype
A3	CS	Portable Prototype	Wearable Prototype
A4	CS	Wearable Prototype	Portable Prototype
A5	Eng	Portable Prototype	Wearable Prototype
A6	CS	Wearable Prototype	Portable Prototype
A7	CS	Portable Prototype	Wearable Prototype
A8	Eng	Wearable Prototype	Portable Prototype
A9	Eng	Portable Prototype	Wearable Prototype
A10	CS	Wearable Prototype	Portable Prototype
A11	Eng	Portable Prototype	Wearable Prototype

Table 7.1: Allocation and sequence of testing of the two heating prototypes.

7.2 Pilot Study

A short pilot study with two participants was carried out before the main study to test the prototypes and the methodology. For the test, the duration of the individual and joint testing of the prototypes was shortened to one day per episode. Nevertheless, the pilot study helped to uncover a prevalent issue with the prototype design and the set-up through their use in a real-life study setting. One pilot study participant repeatedly propped up her elbows on the portable prototype while testing it. The pressure applied through the elbows on the prototype caused a power surge in the carbon fibre tape, which tripped the fuse and caused the power protection of the battery to shut down the power supply. In consequence, the design of the portable prototype was reviewed and the maximum allowable power running through the prototype restricted as described in chapter 7.1.1, which also required the adaptation of the range of the temperature that could be provided by the prototype.

7.3 Results

In this section the results of the analysis of the feedback given by participants in the interviews and evaluation questionnaires as well as of the collected sensor data and IEQ surveys are presented. The questionnaires employed in the study as well as the complete set of time plots of sensor readings can be found in Appendix D.

As the study focussed on uncovering how individuals achieve thermal comfort through the use and appropriation of personal heating devices and its aim was to establish which design-related aspects and affordances support and influence acts of appropriation and adaptation by the user, to what effect and how these are perceived, the thematic analysis that was conducted followed a deductive approach centring around these questions. Interview transcripts and open-ended questionnaire responses were first coded and then mapped out along aspects of prototype use and in particular locations of use, as well as participant experiences and feedback using the wearable and portable heating prototypes in their work environment expressed in form of attitudes and associations, reported advantages and benefits, limitations and shortcomings, as well as suggestions for improvement. In a subsequent step sub themes within these categories were developed and established, which led to the findings reported in the following.

7.3.1 Satisfaction with IEQ and Perceived Thermal Comfort

As in previous studies (see chapter 5), participants were given an IEQ questionnaire at the beginning of the study to assess their perceived comfort in the workplace. The IEQ questionnaire was complemented by additional questions to assess the thermal background of participants and how they adapted to thermal discomfort in their workplace or at home. The satisfaction ratings with different IEQ parameters can be seen in Figure 7.5. Participants rated the personal control over the thermal environment as well as the personal control over the air quality lowest, followed by sound privacy. The aspects with the highest satisfaction rating were the ease of interaction with colleagues as well as the amount of available space and amount of light. Overall workplace satisfaction was rated around neutral. However, participants indicated that the quality of their work environment had a slightly negative impact on their productivity.

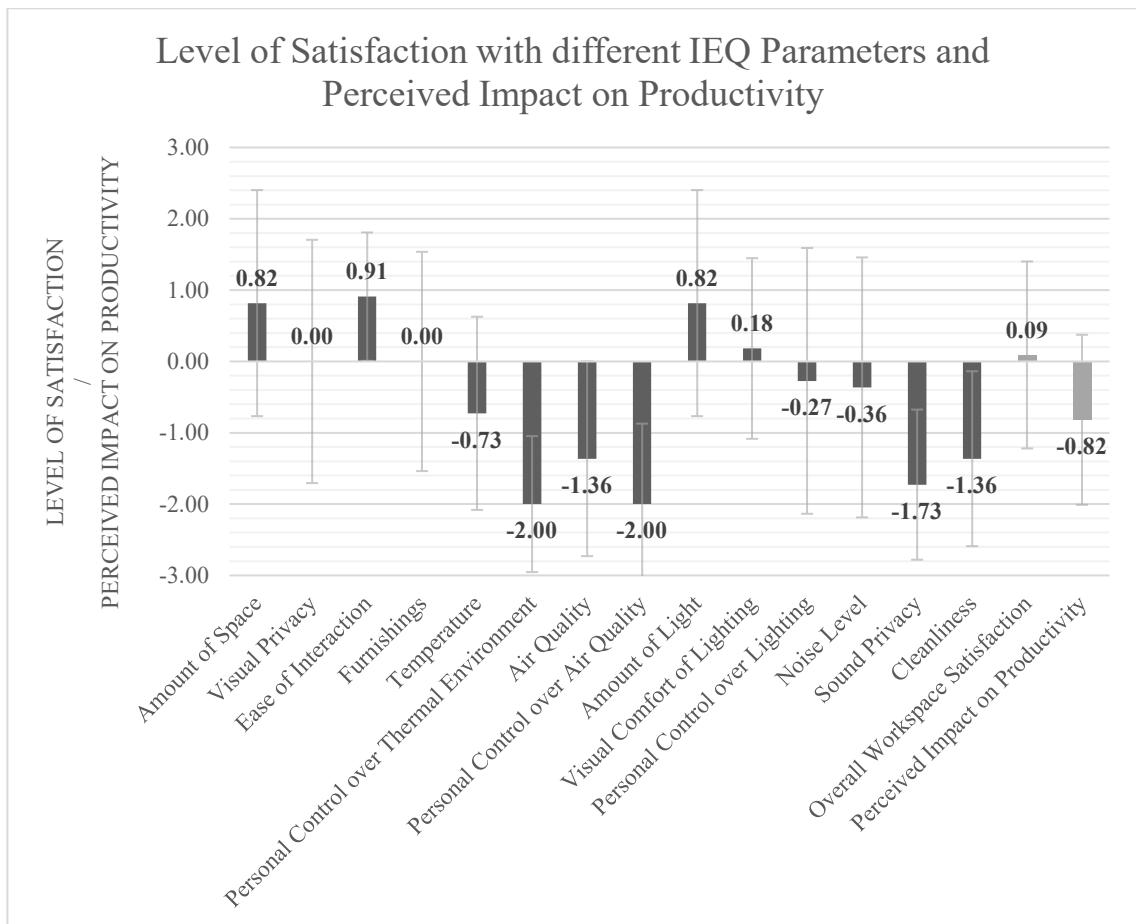


Figure 7.5: Mean satisfaction ratings for different IEQ parameters and the mean perceived impact on productivity.

Asked about aspects regarding thermal comfort in their office in cool/cold weather, seven participants reported that their workspace was often too cold, three participants reported that it was often too hot, and one participant had not experienced a cold period in their office yet. Asked when this was most often a problem with multiple answers possible, eight participants responded in the mornings (before 11am), two participants each at mid-day (11am – 2pm), in the afternoon (2pm – 5pm) in the evening (after 5pm), at no particular time or at other times respectively. The most mentioned sources of discomfort included draughts from windows named by six participants, the heating system not responding quickly enough by five participants, four participants mentioned the thermostat is adjusted by other people and three participants named the incoming sun as a source of discomfort. Furthermore, two participants each named draughts, stuffiness, draughts from vents, and an inaccessible thermostat as sources of discomfort, and one participant each cold floor or window surfaces respectively, heat from office equipment, low humidity or other sources of discomfort. Asked about how cool/cold weather affected them, ten participants in total answered that their hands were too cold, six that their feet were too cold. Five participants of those reported having both cold hand and feet, one of which also reported getting a cold nose.

7.3.2 Reported Behavioural Adjustments and Decisions on Environmental Control

The most cited measure to adjust to feeling cold in the office was adding an item of clothing, which was mentioned by nine participants. Individual participants reported adding up to four different items of clothing, including a coat, gloves, hat and scarf or three items, such as jacket, gloves and headphones to prevent draughts affecting the ears. The most cited items of clothing regarded the upper body, such as coats, jackets, or cardigans. Other reported adjustments against feeling cold included using or switching on the heater, asking for the heater to be switched on or closing the windows. Furthermore, two participants reported making themselves a hot drink to warm up and others to “*enjoy some warm colour*” (A4) or to warm up their hands-on warmer body parts such as the neck. One participant tried not to come to the office when it was cold. For an overview of reported behavioural adaptation measures see Figure 7.6.

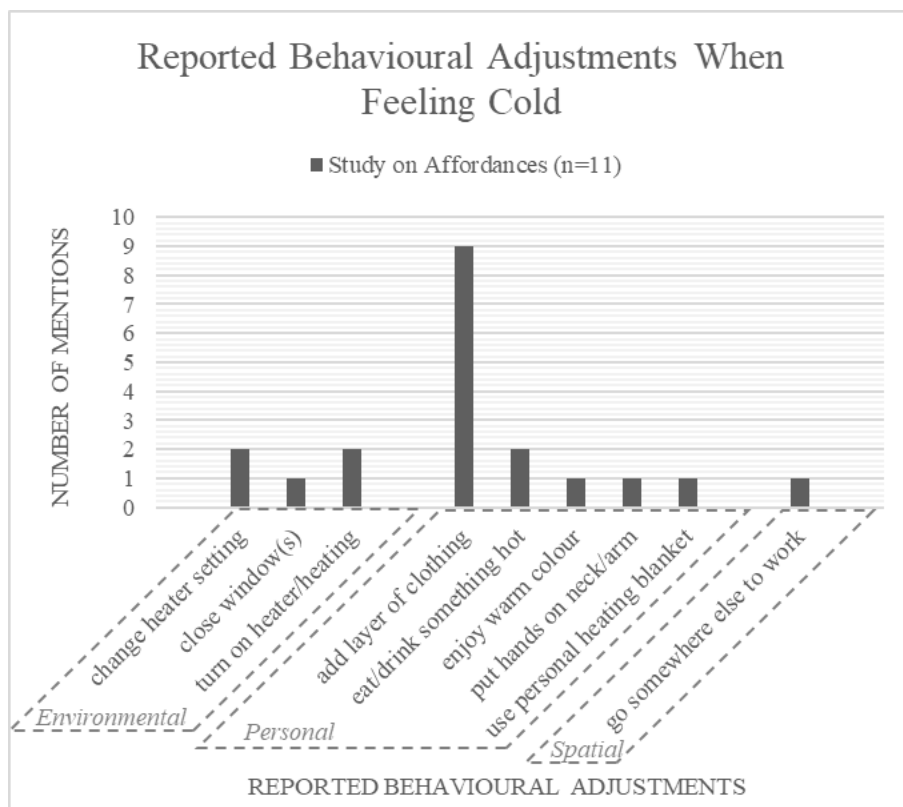


Figure 7.6: Frequency of different self-reported behavioural adjustments when feeling cold (study on affordances).

To gain an understanding of organisational aspects in respect to temperature control and social dynamics in the workplace, participants were asked how the temperature in their workspace was controlled and who decided over it. Two participants answered they did not know. Five participants answered that it was centrally controlled or automatic and one participant mentioned that it was by thermostat. Whereas one participant said that the radiators once centrally switched on could be controlled individually in the office and the thermostat could be

controlled by everyone in the office shared by 40 people, others said the heating was “*out of our control*” (A10) or “*usually on full blast*” (A1) in their workplace. Participant A9 stated that there was no control and that they had a portable heater during the winter months and opened the windows if it was hot.

Reporting on how decisions to change the temperature were made in their office, participant A1 reported that usually a person that feels hot or cold would speak up, and a window would be opened or the portable heater turned on. Another participant, A2, answered, however, that individual people kept changing the temperature level by adjusting the radiator settings or opening the windows, all without asking others in their office. A third participant, A10, mentioned that in their office are many devices, which can be commonly controlled, but some people consult the others, others do not. Furthermore, participant A4 responded that the ones, who could not bear the temperature difference most control the heaters and the ones, who were tall enough to reach the windows would open/close them.

The greatest challenges in achieving thermal comfort in the workplace mentioned by participants included accordingly how to address individual needs and achieving comfort for everyone within a shared environment, the lack of environmental control to adjust conditions, getting a quick response to reported issues.

7.3.3 Time Series Plots: Examples of Thermal Comfort and Behavioural Adaptation

The following section describes individual stories of thermal discomforts and behavioural adaptation, as recorded in the right-now surveys and mapped to the collected environmental and device data. The story of a participant, A1, on three exemplary days during the test period will be reported as example. The full set of time series plots of the temperature graphs over time including the qualitative feedback of perceived comfort at certain points in time for each participant can be found in Appendix D.

Participant A1 worked in an open-plan office in the Computer Science building. The major sources of discomfort she reported during the test period were related to the heating system, which frequently did not provide enough heating or at times too much, and draughts from the windows and vents. She was given the portable prototype first to test. On the second day of testing she started using the portable prototype in the afternoon after having been out of the office all morning (Figure 7.7). At 15:30 she noted that she liked the warm feeling in her back. She switched the prototype off shortly after reporting to feel neither warm nor cold at 16:46. The reason being that sitting with the prototype in the back felt uncomfortable. She reported that she switched on her private heating pad instead.

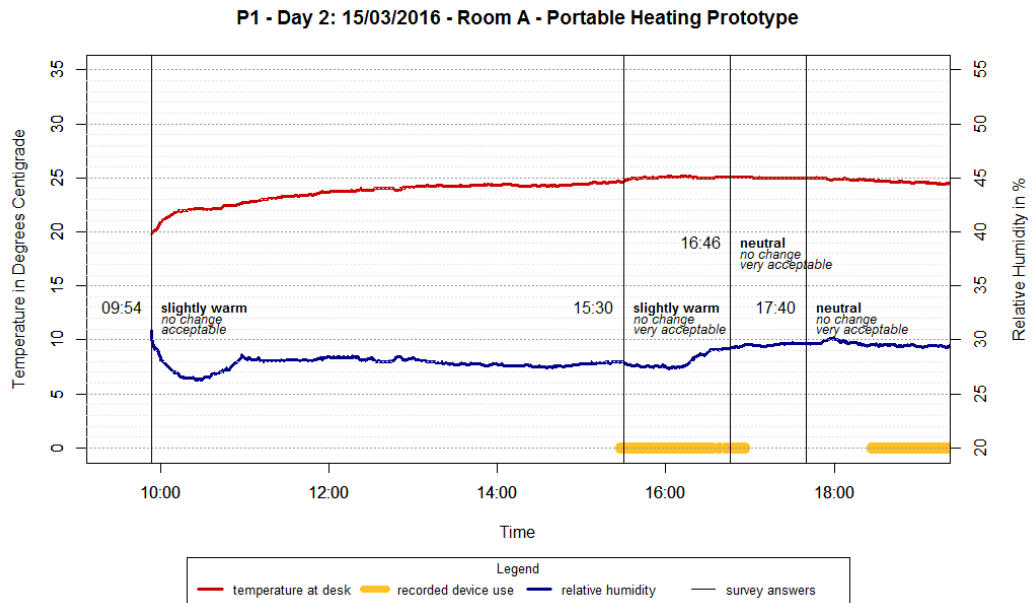


Figure 7.7: Recorded temperature and humidity levels at participant A1’s workplace on the second day of testing the portable heating prototype.

On the first day of testing the wearable heating prototype, participant A1 reported feeling warm all morning because the heating system provided too much heating. She wished to be a bit cooler, although she rated the room temperature as slightly acceptable. She started using the wearable prototype late in the afternoon because she wanted to try it out (17:46, Figure 7.8). At 19:54, however, she reported that she did not feel like using the device anymore and put her office jacket on instead. At that time the heating system did not provide enough heating anymore and the participant experienced draughts from windows and vents.

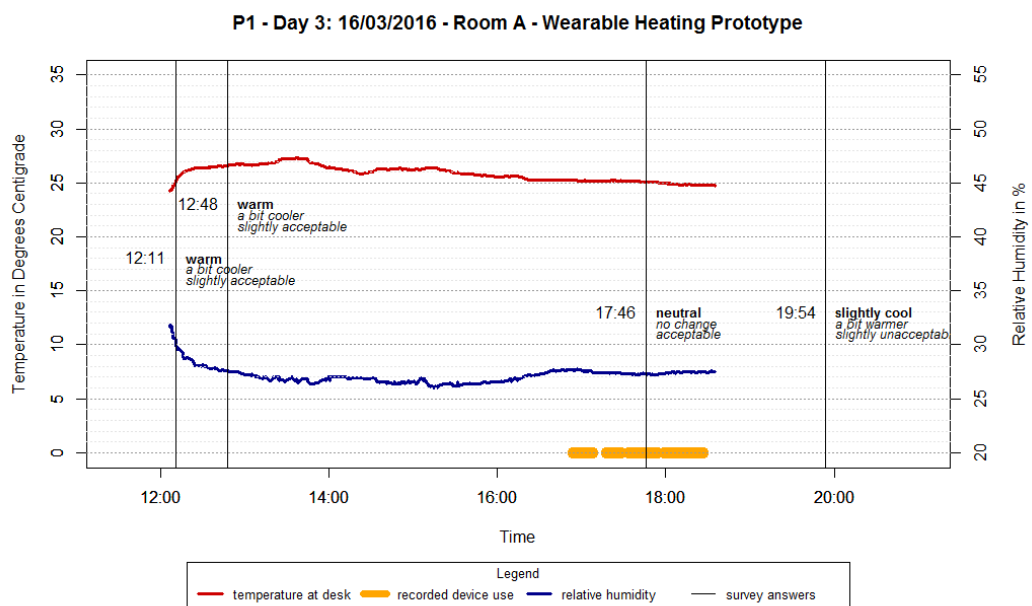


Figure 7.8: Recorded temperature and humidity levels at participant A1’s workplace on the first day of testing the wearable heating prototype.

On the last day of the test period, participant A1 had both prototypes available for use (Figure 7.9). Although she reported no thermal discomfort and no wish for change at 11:08, she switched on the portable prototype. She noted that she wanted to warm her stomach for a bit. In the interview she would report that she really loved having the portable prototype in this location, as it also fit perfectly in the gap between herself and her desk. In the early afternoon she switched devices, reporting at 14:37 that she liked to try the shawl again and that she put it on her lap. However, she noted that she had run out of battery at 16:23. Although she reported feeling slightly cool and wishing to be warmer, no further adaptive measures were recorded.

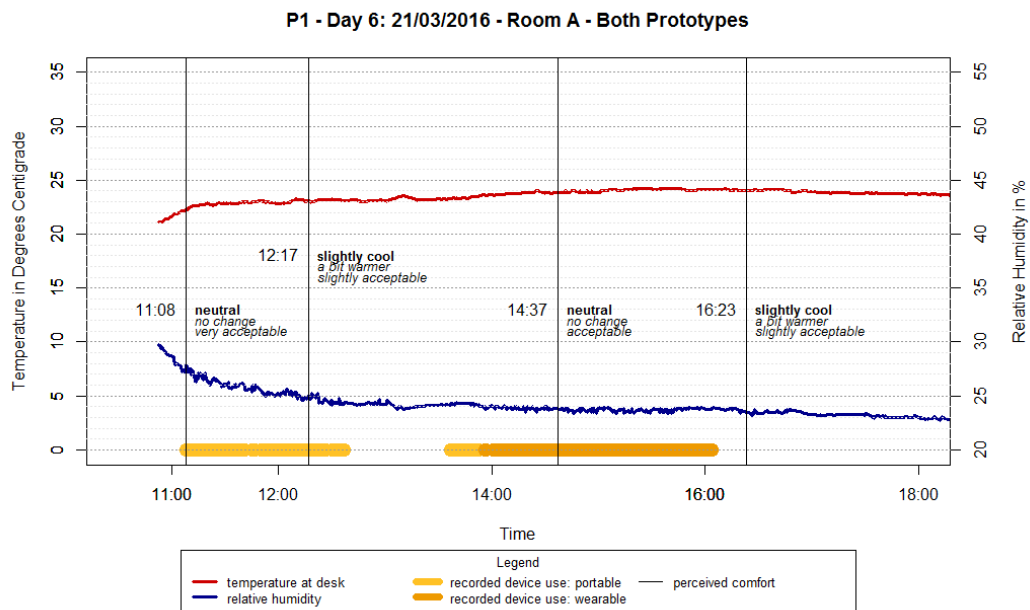


Figure 7.9: Recorded temperature and humidity levels at participant A1’s workplace on the second day of testing both heating prototypes.

7.3.4 Evaluation of the Portable Prototype

Out of the 11 participants, 7 participants reported using the portable prototype for more than one day, 3 participants started but stopped using it and one participant did not use it. Asked on whether the portable prototype had an impact on their feeling of control over their local thermal environment, 10 participants responded that the portable prototype increased or slightly increased their feeling of control (Figure 7.10). However, one participant reported that it decreased her feeling of control. In the open-ended response and during the interview she mentioned that *“body adjustment of myself becomes weaker”* (A9) and explained that using the prototype would warm her up but also make her feel colder afterwards than she normally would without it. All participants responded that having the portable prototype increased their perceived thermal comfort (Figure 7.10). Out of the 11 participants, 1 participant reported that it

very much increased their perceived thermal comfort, for 6 participants it increased the perceived thermal comfort and it did so slightly for 4 participants.

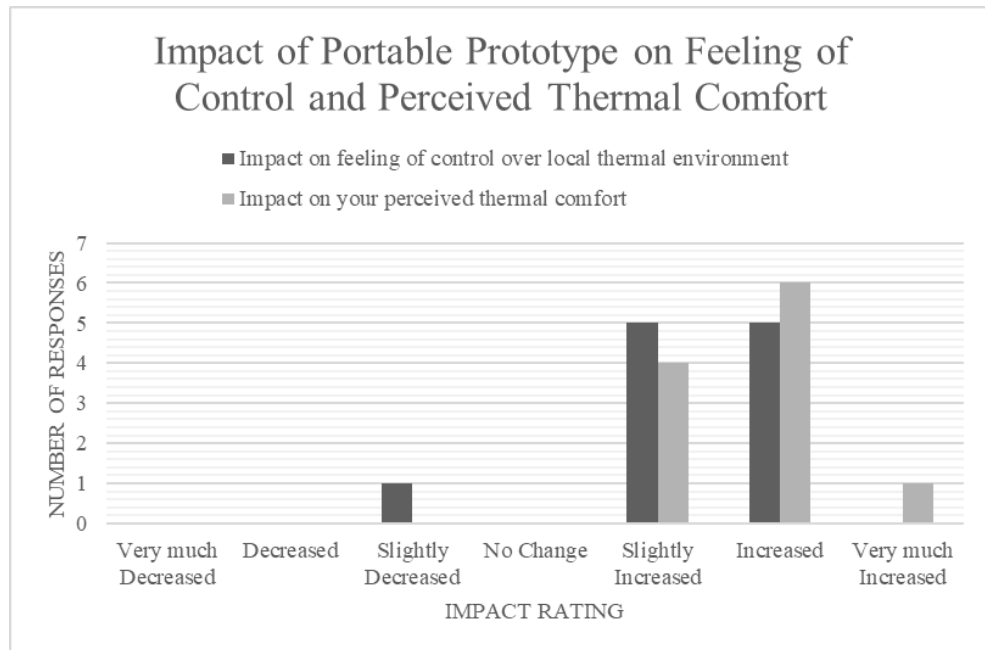


Figure 7.10: Perceived impact of the portable prototype on the feeling of control over the local thermal environment and on the perceived thermal comfort of participants.

Furthermore, participants were asked how satisfied they were with different aspects of the portable prototype, which included the amount of heat, temperature control, portability, flexibility of use, usability in context, effectiveness and intrusiveness (Figure 7.11). Participants were satisfied to varying degrees with all aspects. The highest rated aspect was the amount of heat the prototype provided. However, responses also showed the highest standard deviation among all aspects, which was 1.5. Although most participants were satisfied at various degrees with the amount of heat the prototype provided and one responded with neutral, one participant was dissatisfied, as he wanted the prototype “*to go hotter*”. The lowest rated aspects were the portability and flexibility of use of the prototype. Participants described it as “*bulky*” (A3, A5) and “*not that convenient to carry*” (A4). Furthermore, participant A4 reported that they could not “*change the formation to the shape I wish*” and could only “*take it as what it is*” (A4).

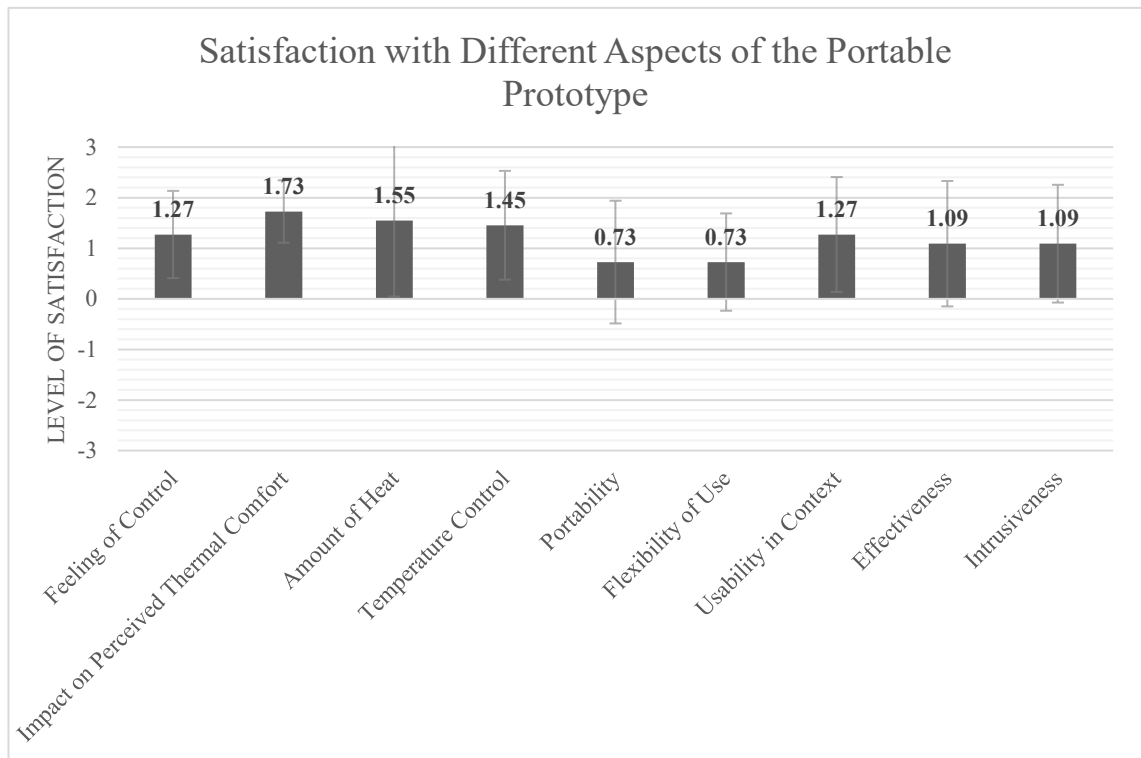


Figure 7.11: Mean satisfaction with different aspects of the portable prototype.

Reported Locations of Use of the Portable Prototype

The portable prototype was used by participants on six different body locations during the trial: the lower back, the belly, holding it in their arms against the upper body, the hands, the forearms, as well as on the lap or upper legs. Furthermore, participants suggested the feet and the head-shoulder area as two additional areas on which they would have liked to use it but did not do so during the study. Seven participants reported testing out or using the prototype in two different locations, three participants used it in three different locations and one participant in one location only. However, most participants reported a position they used most or found more convenient. For example, participant A10, who reported using the portable prototype at the lower back and on the lap described his struggles finding a convenient position during the interview in detail:

“So, I thought the first few minutes, I really did not know what to do with it and was very like ‘no, this isn’t right, I won’t get it fully down [beneath the desk]’ and once I put it there [at the lower back] it was really nice. I liked it there.” (A10)

The most frequently cited body location tried was the lower back with seven participants reporting that they used the prototype to heat this area (Figure 7.12a), followed by the hands cited by six participants (Figure 7.12b +c) and the lap or upper legs cited by five participants (Figure 7.12b). Out of the seven participants using the portable prototype at their lower back two stated that it helped against back pain (A2, A11) and one that it would help her sit better (A3). One participant mentioned that she really liked the heat in her back (A1) another one that

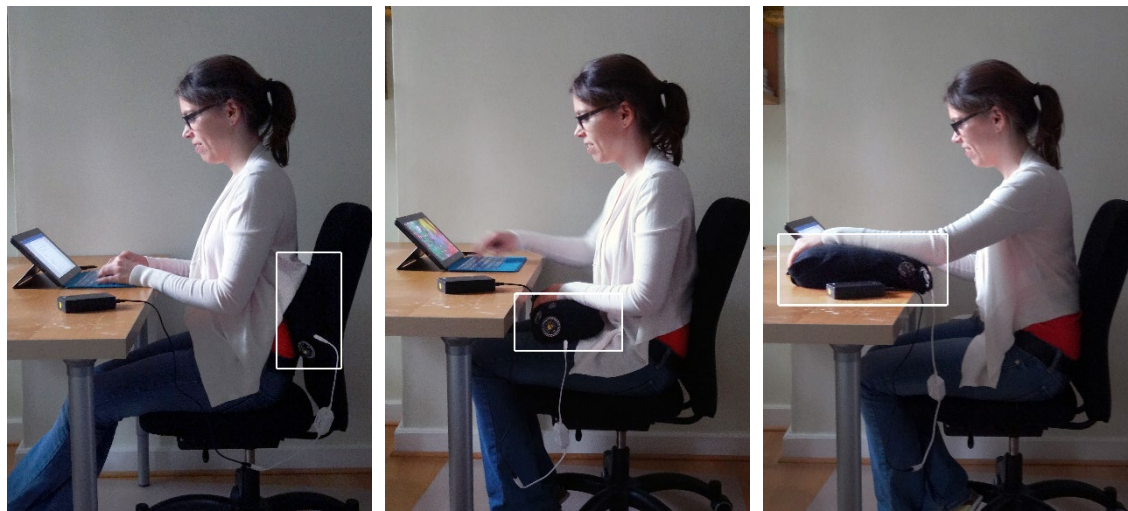
she placed it at the lower back because the heat in this location would the whole body make feel better (A4). One participant stated that he used it at the back because it was convenient (A8). However, two out of the participants, who used the portable prototype at the lower back also mentioned that it was not comfortable (A3) due to its bulkiness and led to an uncomfortable sitting position (A1). One participant was afraid to squash the sensing circuit (A2) in this position.

Out of the six participants using the portable prototype to warm and rest their hands on it, three also used it to rest and warm their forearms (A5, A6, A7). Participants reported that they would rest their hands on the prototype when these were cold (A2, A5, A6) or when they were reading (A2, A8), watching something (A8), or talking to someone (A7) or when they were tired from typing (A7). Two participants reported scrolling or typing with one hand and resting their other hand on the prototype (A2, A11). Two participants used the prototype as a base to rest their hands and forearms on while typing (A5, A6). Most participants rested the prototype with the heating side up on their laps. However, one participant each reported having it next to their keyboard or trackpad (A7) or on the handle of their chair (A11).

Two of the participants, who used the portable prototype for warming their hands, also used it to warm their upper legs (A2, A6). Participant A2 reportedly kept turning the prototype to alternate heating lap and hands. Other participants, who reported using the prototype on the lap, did so to rest it there while typing and writing (A4) and to warm their legs when they felt cold (A9). However, participant A9 reported that her legs kept feeling cold even when using it. She also mentioned that this was the only position where she could put it, as she would sit at the edge of the chair and never touch its back.

In addition to these more frequently reported body locations, two participants reported to having sometimes just held the prototype in their arms (A4, A9) when they were not reading or writing. One participant stated that she “*really loved having this to warm the belly*” (A1), as it fit perfectly in respect to the height of their desk and gave her comfort.

Although six participants stated that having the prototype did not interfere with their work in general or once they had found a place for it (A10), some participants were aware that they had something on them (A2) and were not quite comfortable with having a big cushion at the chair (A3).



a) At the lower back

b) On the lap

c) On the table

Figure 7.12: Three most commonly used locations to place the portable prototype: the lower back (a), on the lap (b) and on the table (c).

Reported Patterns of Use of the Portable Prototype

In the evaluation questionnaire, participants mentioned different times, aspects, and occasions during which they used the portable prototype. Two participants reported using it in the morning right after they arrived at the office (A4, A8). Three participants used it during the day (A2), after about 2pm (A5) and in the afternoon (A10). Two participants used the prototype in the evenings (A1, A2). Furthermore, some participants reported using the device to improve their comfort, when they wanted to feel warmer (A2), rest their hands on something warm (A7) or when they felt cold (A8). Other participants responded using the prototype to take a break from reading (A5) or from typing (A7) or after they had been sitting for a while. Two participants reported the frequency or duration for which they used the prototype: A5 reported using it for about 20 to 30 minutes and A7 to have used it 2 to 3 times a day. Figure 7.13 gives an overview of the recorded device use for each prototype with a median duration of 41.5 minutes recorded for the portable prototype and of 44.5 minutes for the wearable prototype. The recorded use of the prototypes shows large variability in usage times, with a quarter of uses of the prototypes having been recorded for extended periods of time of more than 90 minutes for the portable and more than 130 minutes for the wearable prototype, while another quarter of recorded uses were for short durations of less than 11 minutes (wearable prototype) and 19 minutes (portable prototype).

Portable and Wearable Prototypes: Recorded Duration of Use

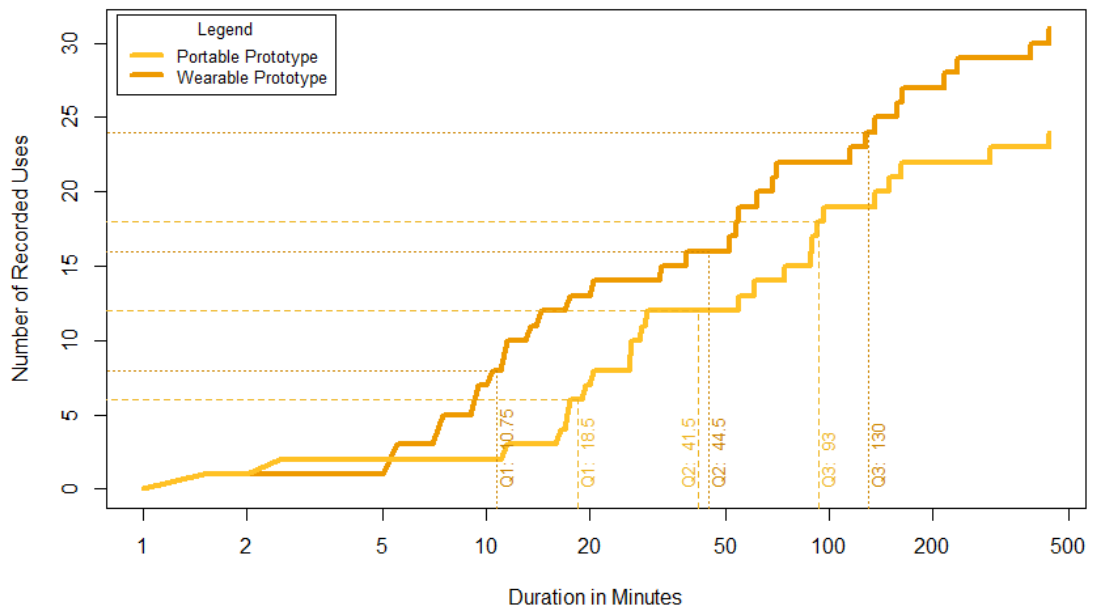


Figure 7.13: Recorded duration of use for the portable and wearable heating prototype as cumulative frequency graph.

Reported Advantages and Benefits of the Portable Prototype

Asked to provide feedback on the advantages and benefits of the portable prototype, six participants reported positively its warmth, in specific on the amount of heat it provided (A1, A6, A7), that it heats up quickly (A1) and helps to keep warm (A3, A9). However, participant A9 also noted that although it will keep her warm, it also weakens the ability of her body to adjust. During the interview she explained this as follows:

“Let’s say, for example, I like to drink hot water. But if I always drink hot water, when I drink the normal temperature water, I will feel ‘oh, it’s so cold!’ but it is not. So, when I feel cold, I use this prototype and when it’s normal temperature, I may feel cold.” (A9)

Furthermore, participant A1 highlighted its functionalities, which included the possibility to adjust the power, that it was portable, and that it had a long battery life.

Attitudes and Associations towards the Portable Prototype

The characteristic of the portable prototype, participants commented most positively on was its texture. It was described as “nice” (A1, A8, A10), “fluffy” (A1), “subtle” (A10), “soft and warm” (A7), and as “anti-stress” (A2). Participant A8 liked “the cosiness of a pillow and heater”. Participant A2 stated that she liked “the actual feeling of it” and that she was sometimes grasping it because of its warmth. Also, participant A4 reported that it was comfortable to hold and that she quite enjoyed holding it in her arm. She stated that when she was thinking grabbing and playing with something helped her think. Also, she loved “the warm

and soft feeling of touch". Participant A7 reflected during the interview on his use of it saying that he was using it "*just as a relaxation device rather than heating*". The relaxation effect was also mentioned by participant A11 in the questionnaire. In addition, two participants associated the portable prototype with a pet:

"I think I kind of felt that I had something on me, cause I was holding it. So, I felt like I had a cat or something." (A2)

"When I was four or six years old I usually like to holding my little dogs on my lap top. So, when I knew this prototype it reminded me that little dog." (A4)

Reported Limitations and Short Comings of the Portable Prototype

Participants reported the following limitations and short comings of the portable prototype. Regarding its form they stated that it was bulky (A5) and not that convenient to carry around (A4). Accordingly, the wish for it to be smaller was addressed (A5). However, other participants commented that the surface area was too small, as it did not cover the back area when they felt cold (A3) or they therefore had to move it a few times (A8). They would have preferred the heating area too be larger (A8). Two participants commented on the shape, and that it lacked flexibility, as they could not change it to the form they wished (A4) or which they would have preferred, for example, be more belt-like (A9). Feedback on the amount of heat provided by the prototype were divided. For one participant it was not hot enough (A5) while for another it provided enough heat (A2) but they would have wished for the heating to be on both sides rather than just one.

The most often reported short coming and limitation for the use of the prototype was the external power supply (A6, A11), the size and heaviness of the battery (A2), as well as the cable that connected it to the prototype (A1, A7). Also, the sensing circuit inhibited the use of the prototype (A2) or was just felt being annoying (A11). Its placement at the front side of the prototype led some participants to take particular care, as they were afraid to break it (A2) and therefore, for example, did not dare to use it at their back. Another participant reported that the portable prototype limited the mobility at their desk and their flexibility in sitting (A11). They reported requiring the prototype at a specific height at their lower back but whenever they tried to sit upright, the prototype kept falling and they had to readjust it. In consequence this participant wished for some form of attachment of the prototype to the chair.

Suggestions for improvement for the Portable Prototype

In accordance with the limitations and short comings that were reported, participants suggested the following improvements. In respect to the power supply and battery they suggested having battery and temperature control integrated into the prototype (A1, A7) or that it was smaller (A9). One participant suggested to adjust the length of the cable (A2). Participants also stated that the cable length was less of a problem with the portable prototype than it was with the wearable one. They used the portable prototype closer to the table, where they could rest the

battery, and they did not move it as much as the wearable, as it was resting on the lap. Furthermore, it was suggested to move the sensing circuit to the side of the prototype, so it would not be squashed by leaning on it, for example, with the back (A2).

In respect to the form of the prototype, some participants suggested for it to be smaller (A5), others for it to have a larger heating area (A8) or heating on both sides (A2). Three participants mentioned different forms for the device, such as a belt (A9) and a trackpad (A7) or mouse mat (A5). One participant mentioned that it should be attachable, for example, to the back of the chair (A11). Participants also suggested that the size, shape and/or colour of the cushion-like prototype (A7) or its cover (A1) could be customisable and a flexible sheet of heating could cater for all sorts of pillows (A8). One participant stated in this respect:

“If everything is inside the pillow, it would also be cool to have a pillow cover for customisation and then I would even take it somewhere” (A1)

Regarding the heating element of the prototype, one participant suggested to have a reactive heating element (A4), which would respond to touch and gestures *“like an alive creature”* (A4). Temperature would increase in the part that was touched and would go slowly back to default when released. During the interview, the participant elaborated further on the idea of having some embedded technology and design, which detects body and environment temperature as well as touch and responds in an interactive way.

7.3.5 Evaluation of the Wearable Prototype

Out of the 11 participants, 8 participants reported using the wearable prototype for more than one day, 2 participants started but stopped using it and 1 participant did not use it. Asked on whether the wearable prototype had an impact on their feeling of control over their local thermal environment, nine participants responded that the portable prototype increased, very much increased or slightly increased their feeling of control (Figure 7.14). However, as in the evaluation on the portable prototype, the same participant (A9) responded that it slightly decreased her feeling of control. The participant, who indicated not having used the prototype during the test period did not complete the questionnaire.

All participants responded that having the wearable prototype increased their perceived thermal comfort (Figure 7.14). Out of the 10 participants, who used it, 2 participants reported that it very much increased their perceived thermal comfort, for 4 participants it increased the perceived thermal comfort and it did so slightly for 4 participants.

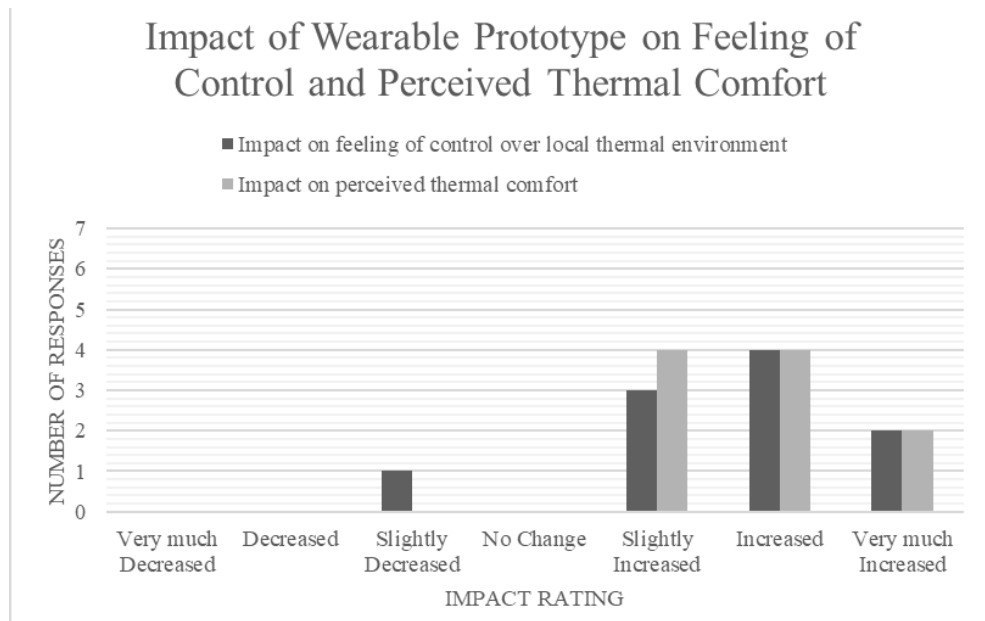


Figure 7.14: Perceived impact of the wearable prototype on the feeling of control over the local thermal environment and on perceived thermal comfort.

On a scale from very dissatisfied (1) to very satisfied (7), participants were asked how satisfied they were with different aspects of the wearable prototype. Aspects rated included the amount of heat, temperature control, wearability, flexibility of use, usability in context, effectiveness and intrusiveness (Figure 7.15). On average, participants were slightly to satisfied with most aspects. The highest rated aspects were the effectiveness of the prototype and the amount of heat it provided. The lowest rated aspect was the intrusiveness of the prototype.

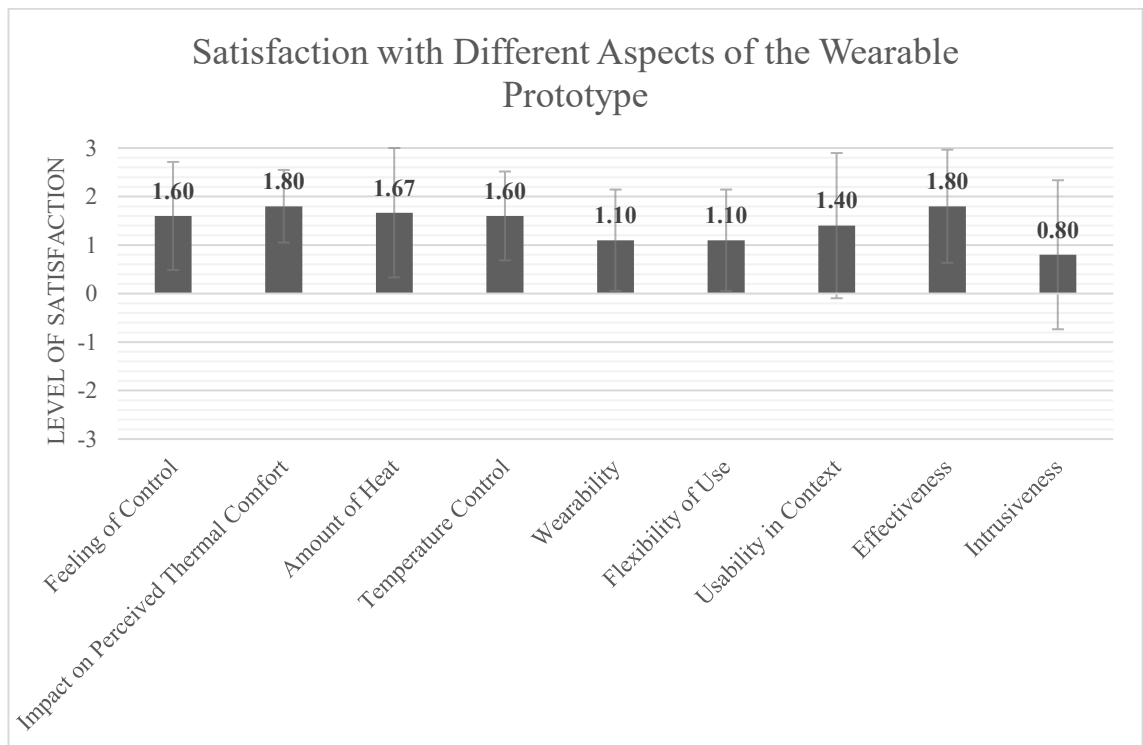


Figure 7.15: Mean satisfaction with different aspects of the wearable prototype.

Locations of Use of the Wearable Prototype

The participants reported using the wearable prototype on five different body areas: the back (shoulders and upper back), the lap and upper legs, the upper body, hands, and the feet. Five participants reported only one body area they used the wearable prototype on, five participants mentioned two different body areas and one participant mentioned three different body areas. The back (Figure 7.16a) as well as the upper legs (Figure 7.16b) were the positions most tested by six participants each. Two participants each reported using the wearable prototype to warm their upper body or their hands. One participant reported using it to warm their feet in combination with the legs. Five participants using the wearable prototype to warm their back reported wrapping it around themselves (A1, A2, A3) and using it like a cape (A8) or scarf (A9). One participant stated that they liked *“the idea of wrapping the blanket around me or any way of having it on me”* (A2) and another one, who did not use it on their back during the study due to a fear that it might draw too much attention, stated that they would have liked to wear it like a cloak (A4). Furthermore, two participants reported putting the wearable prototype over the backrest of their chair (A3, A7) to warm their back while leaning on it. Participants mentioned that positioning the wearable prototype on or at the back helped against a cold back and more in general proved a strategic position to alleviate overall thermal discomfort:

“So, if I would feel really cold in the office, maybe I would use this one [the wearable prototype] over the back because it has a larger area than this one [the portable prototype].” (A1)

However, one participant mentioned that having the wearable prototype in the back made them sometimes feel very hot (A9). Also, it was stated by the two participants using it at the back of their chair that having it at the back did not interfere with sitting (A3) and that it was *“just there”* (A7), although other participants found it more difficult to use and harder to handle when placed at the back (A1, A2) due to the wires being too short or hanging, the battery dragging it down (A1) and the fear of breaking the circuits or dropping the battery (A2).

The six participants, who used the wearable prototype to warm their legs, reported using it across their legs covering the lap and upper legs as well as falling over the knees. Two participants reported that it was their legs that got or felt mostly cold (A6, A9). Other participants stated that it was nice (A1, A10), as it warmed the legs (A1).

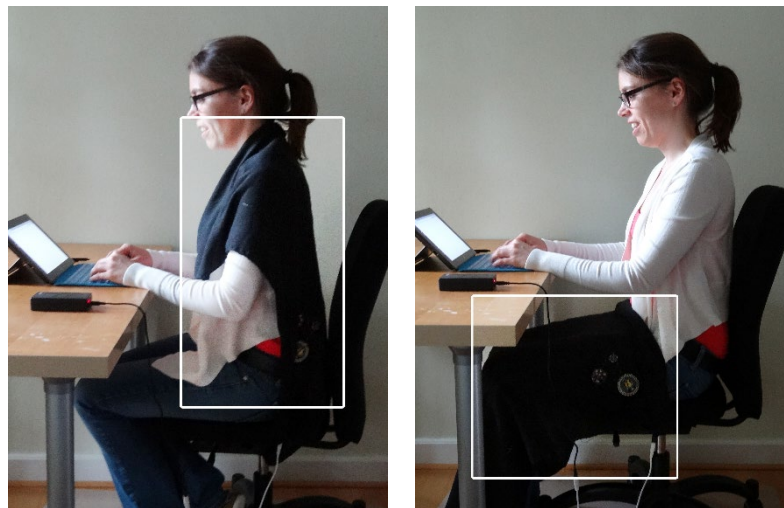
Participant A10 mentioned that he used the wearable prototype solely in this position, as it was under the desk. Other participants mentioned that it was easier with the cables and the battery could be placed on the desk (A1, A2) or in a drawer (A1). Also, the sensing circuit could be placed on top to prevent damage (A2). Some participants reported adjusting its length by folding it to the preferred size and thickness:

“So, it's always my legs that get cold for some reason or feel cold. So, it was nice that I could just sort of adjust the length that I wanted it across, you know.” (A6)

Participant A4 stated that they first folded it but then upon realising that it only warmed the upper legs, but their feet still felt cold and therefore unfolded it again to cover their legs and their feet. Another participant explained that she would also pull the wearable prototype up towards the shoulders (A6) and thus cover also parts of her upper body with it. Participant A11 reported using it mainly to cover his chest and upper body (A11). However, it did interfere with his work-related activities, such as using the mouse and typing and thus did not stay very well in place and kept sliding down. Furthermore, two participants reported warming their hands with the wearable prototype (A2, A5). Whereas one participant would place her hands-on top of the wearable prototype while it was covering her lap (A2), the other participant kept the wearable prototype in a heap on his desk putting his hand inside (A5):

“I could shove my hand right in the middle of it. Basically, so it was completely surrounded by heat rather than just laying on top.” (A5)

The participant also reported switching hands to warm whichever one was feeling colder while working (A5). Again, participants tried the prototype on different body locations, either to see if they could find a more convenient position for it based on the characteristics of the prototype and its power supply, the work-related and physical context or in response to changing needs and requirements. The position most often reported as the more convenient one to place the wearable prototype on was the lap and upper leg area with five participants (see Figure 7.16b) followed by the back reported by three participants (see Figure 7.16a). However, due to its size the wearable prototype allowed participants to use it across several parts of their bodies at the same time instead of having to switch.



a) At the shoulders and back

b) On the legs

Figure 7.16: The two most commonly used locations to place the wearable prototype: the shoulders and back (a) and on the legs (b).

Patterns of Use of the Wearable Prototype

Participants reported using the wearable prototype at different times during the day: in the morning (A9), the afternoon (A6) and from around 2.30pm onwards (A5), as well as in the evening (A2). Participant A3 responded using the wearable prototype for two or more hours a day. Other participants mentioned they used it once a day (A9, A10) and one participant said it was hanging over his chair all the time (A7). The reasons given for the use of the wearable prototype were feelings of discomfort caused by environmental conditions, for example, the cold (A11) or cold weather (A4), not enough heat from the heating (A4) or there was cold air flow (A11).

Reported Advantages and Benefits of the Wearable Prototype

Participants commented positively on the wearable prototype's flexibility of use (A1), in particular that it was multifunctional like a blanket as such that it was easy to move around and to place anywhere on the body (A6), and its versatility (A2), in as such that its length and size could easily be adjusted by folding it (A6), which at the same time also allowed to make it thicker and create double layers, which increased the heating effect (A4). In general, its size was named as another advantage, as it allowed to cover and warm a larger body area (A6), which helped to alleviate cold more effectively and increase thermal comfort in inclement thermal conditions:

"So, if I would feel really cold in the office, maybe I would use this one [the wearable prototype] over the back because it has a larger area than this one [the portable prototype]." (A1)

Furthermore, it was titled as lightweight (A1), not heavy (A8), comfortable and convenient (A8). One participant positively reflected on the wearable prototype's material and the fact it would let the air flow through and would not make them sweat (A11):

"So, I wasn't sweating, and it was a good texture of cold weather and the warm thing, this warm thing." (A11)

Participants also commented positively on its simplicity, that it was more like a blanket (A3), which made it easy to use it anywhere (A6) and not designed as an item of clothing, which would have limited its wear (A8):

"I think this is like pretty straight forward and it's better not to have this as like a sweater, something that you can put your arms in. So, this is just like a piece of fabric. That's, I think, the nice thing about this because you can use it as the way you want it. It does not limit you to wear or do something. You can fold it, do, or sit on it or everything. So, I think, this is pretty simple." (A8)

Its characteristic of being thin in combination with the possibility to fold it also meant according to participant A5 that it was smaller and flatter and thus easier to find a place for.

A participant, who had used the wearable prototype over the back of his chair rather than putting it on his body furthermore stated in respect to its ease of use:

"The shawl just was there." (A7)

"Because shawl doesn't require me actively putting a hand on it, then I would be using it more. Because I would just turn it on." (A7)

The functionality it provided to adjust the temperature was named as another benefit of the wearable prototype, as it allowed to adapt the amount of heat in correspondence with the body's own thermoregulation. Participant A3, who regularly biked to the office explained she would use it instead of a jacket and switch it on when starting to feel cold after being hot from the bike ride. It also helped to reduce discomfort in inclement thermal conditions (A4) and was reported to increase performance (A11).

Attitudes and Associations towards the Wearable Prototype

Participants likened the wearable prototype and their use of it to how they would use items of clothing, such as a jacket (A3), cloak (A4), scarf (A9), shawl (A7), or cape (A8). Accordingly, participants stated that with the wearable prototype it *"was more just wearing it"* (A2) and that it was easy to move around. However, its benefits, i.e. its versatility, flexibility and ease of use, were often described in comparison and contrasted to an item of clothing. In its form and functionality, it was consequently also likened to a piece of fabric (A8) or a blanket (A6), with more non-descript form factor, which was also described as multifunctional.

Reported Limitations and Short Comings of the Wearable Prototype

The most often reported short coming in respect to the wearable prototype was again the power supply. Participants experienced issues with the cabling and the weight and size of the battery: one participant reported that the length of the cable was not long enough when putting it around their shoulders (A2). She stated that *"if I would move then I was afraid the heavy battery would drop on the floor"* (A2). Other participants mentioned that *"the cables were a bit more hindering than with the pillow because the shawl was so light and thin"* (A1) and found the battery annoying because it pulled the prototype down (A3) and restricted where the prototype could be placed (A6). Participant A6 elaborated on the struggles during the interview in a bit more detail:

"I think maybe I would have liked to get up and walk about with it on. Because I felt like I had to place it on my lap, which it was good for because I could put the sort of battery on the side. But then I would have to move the battery with having to move this and - I just felt if it was attached to this [the wearable prototype], it would make it a lot more versatile to move around a lot easier. I just felt that the battery restricted it sometimes." (A6)

On a similar note, other participants mentioned that the wearable prototype limited their mobility at their desk (A11) and that they did not have a pocket to carry the battery in when they walked around with it as a short coming (A4). In addition, the former participant shared that the weight distribution of the prototype was not proper and that he could feel the circuits and wires

inside the wearable prototype, which made it not very comfy and made them feel annoyed (A11).

In respect to the functionality of the wearable prototype a short battery life (A11) was reported as a limitation as well as that it did not get very warm (A1). One participant shared that while using the wearable prototype he noticed that it was more his hands that were cold and that the problem was rather a draught than the ambient temperature (A10). During the interview he explained the limitation of the prototype he experienced as follows:

"I mean it just generally made me, it, you know, it took the edge off. Although it wasn't, you know. I thought the hands separated. I hadn't realised how, like it was my hands that would get cold until I'd start to do something about it and that." (A10)

Regarding its form, participant A5 mentioned that he would have liked it to have been smaller, approximately mouse mat sized just to warm his hands. Two participants commented on the appearance of the wearable prototype. One participant stated that she preferred a more delicate appearance (A9), another that she was afraid it was too obvious and would have drawn the attention of other people, who would have started asking questions (A4). These considerations hindered her to take the prototype with her, although she would have liked to even when leaving her desk only temporarily.

Suggestions for Improvement of the Wearable Prototype

Suggestions for improvement of the wearable prototype were based on the reported shortcomings and primarily focussed as in the case of the portable prototype on the improving power supply related issues. Participants had reported their struggles with the cabling and battery, accordingly they suggested having a longer cable, which would make the wearable prototype more versatile, as the battery could be placed on the floor (A2), or alternatively having a bag for the cable and battery, which could be fixed to the chair to make the handling a bit easier (A1). Participants also suggested for the wearable prototype to have battery and circuits integrated in the prototype itself (A11). Participant A4 went further and suggested to use a material for the prototype that would absorb energy and release it to *"avoid using external battery to power it and it will become more portable."* (A4).

Another aspect mentioned regarded the size of the wearable with participant A5 suggesting combining a mouse mat with heating (A5). Also, the appearance of the prototype received suggestions for improvements including that the prototype could change colour according to the body temperature (A4). Elaborating further during the interview, the participant suggested that the wearable could change to a red or orange shade when feeling cold:

"When I feel cold I like to see some red colours or orange colours because it is close to the sun and give me the hint that some warming temperatures or the warm light come towards me." (A4)

In turn it could turn blue or green resembling the ocean, fresh air from woods or grass when being too hot (A4). Furthermore, the participant suggested having responsive heating based on the user's body temperature:

"so, maybe if the prototype can detect my body temperature, if my body temperature is about the normal level so it will stop generating the heat and the colour will change from the warm colour to the cold colour." (A4)

7.3.6 Comparison between Portable and Wearable Heating Prototype

Although, both prototypes were overall rated positively, differences in the rating of polled aspects occurred. The impact of the wearable prototype on the feeling of control over the local thermal environment as well as the perceived thermal comfort was rated slightly higher than that of the portable prototype (Figure 7.17).

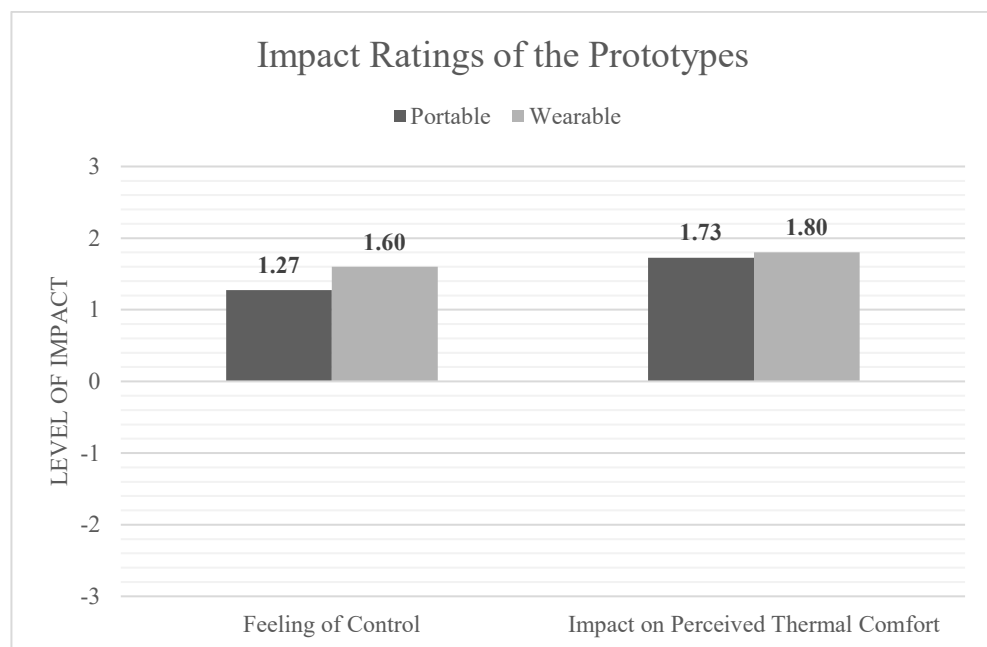


Figure 7.17: Comparison of reported impact on feeling of control and perceived thermal comfort between portable and wearable prototype.

On average, participants expressed a higher satisfaction with the wearable prototype in respect to the amount of heat, temperature control, portability/wearability, flexibility of use, usability in context and effectiveness (Figure 7.18). The difference in satisfaction ratings between the wearable and the portable prototype was particular pronounced for the effectiveness of providing thermal comfort.

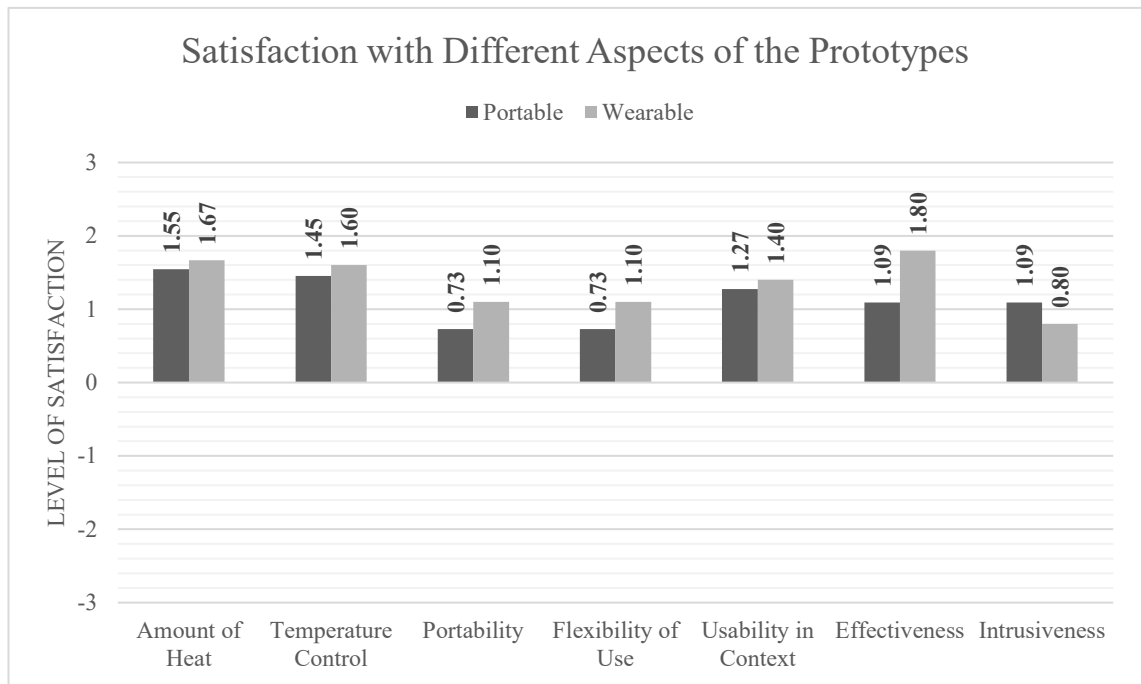


Figure 7.18: Average satisfaction ratings with different aspects of the prototypes in comparison between portable and wearable prototype.

Choice of Preferred Prototype and its Reasonings

In the third part of the experiment, participants were given both prototypes but only one battery. Participants were asked during the interview which one they used during this period to establish preferences between the prototypes. Most participants expressed a clear preference for one prototype feeling compelled to give reasons or arguments for their preference, which reflected the advantages and benefits of the prototype of choice but also compared it to the less preferred one.

Nine out of eleven participants reported having primarily used the wearable prototype during this period. However, only eight of these also expressed a clear preference for the wearable prototype. Participant A4 stated that she preferred the portable prototype, although she had used the wearable one:

"I preferred to use this one [portable] but actually I used this one [wearable]. Because yesterday when I'm feeling cold I like to have some warm. But because I need to write and typing and reading the books and papers, so I can't spare my hands to hold it or crush it so that's why I use this one [wearable] to cover my leg and feet."
(A4)

The ability of the prototype to better alleviate thermal discomfort and feeling cold was mentioned by four other participants (A3, A5, A6, A10) when arguing their choice of prototype. Two participants mentioned that the heat was just right (A6) or that having this in the back when feeling cold was enough (A3). One participant also suggested that it would help alleviate pain in the back or neck (A9). The wearable prototype's versatility and adaptability was

mentioned by three participants (A2, A6, A9). Aspects relating to the convenience of participants using the prototype, such as that it did not interfere with sitting (A3), it was easier to handle (A5) and that it did not need too much active attention (A7) were given three times. Material properties and properties of the form of the prototype, such as that it covered a wider body area (A6, A8), that it was not heavy (A8), that it took up less space than the portable prototype (A5) and that its fabric allowed the air to flow through and thus did not lead to sweating (A11), were also given as reasons for the preference of the wearable prototype over the portable one.

In contrast, participant A1 expressed an explicit preference for the portable prototype. Her main reason for preferring this prototype was that she had found a position for it, which was both very convenient, as it fit neatly in between her and the desk, and comfortable, as it rested with the heated side against her belly:

“I really like it that I can just put it [the portable prototype] there and here is the desk and it is just so really comfortable.” (A1)

One participant reported actively switching between the devices depending on which body part felt cold (A2). Participant A10 distinguished differences in comfort related to his use and the affordances of the two prototypes, between comfort as in being comfortably warm and comfortable as a state. He explained the difference as follows:

“So, it was actually, it actually got quite cold. It got quite nasty. But I used this one [the wearable prototype] cause this one was more about making me warm, whereas this one [the portable prototype], this one was making me comfortable, which I know that seems odd to distinguish and I don’t know quite how doing it. This one [the portable prototype] I kind of get bad back and it was really nice to have it there to have a little bit warmth here, but I didn’t think it necessarily stopped me being cold, if you see what I mean. It was nice to have it there, but it wasn’t like ‘Actually, this room is cold and now I don’t feel cold’, whereas this one [the wearable prototype] heated me up.” (A10)

7.4 Discussion

In shared environments, behavioural measures constitute the most common way for individuals to deal with thermal discomforts, as they allow to respond to external comfort factors within a short response time frame and also in case of only temporally occurring factors of discomfort (Parsons 2003; O’Brien & Gunay 2014; Stazi et al. 2017). However, the ability of occupants to take active control is very often inhibited by constraints of the environment. In the context of our study, the constraints faced by participants were a lack of control over the local thermal environment using environmental controls either because temperature was or was considered centrally controlled or unclear to occupants, and constraints of the larger social workplace setting, which made taking control over commonly shared controls more difficult and placed a social cost on it. In consequence, how to address individual needs and achieving comfort for

everyone in a shared space was considered as the greatest challenge in achieving thermal comfort.

Results from the pre-study comfort assessment showed that in consequence behavioural measures taken to alleviate discomfort in respect to feeling cold occurred predominantly on a personal level in form of adding layers of clothing. Into this context, two personal thermal devices were introduced for participants to test and use in times of thermal discomfort. Responses showed that having the prototypes increased perceived thermal comfort and feeling of control over the thermal environment. However, reports on the use of the prototype uncovered the process involved in achieving thermal comfort through the use and appropriation of the thermal devices, as well as aspect involved in respect to the perception of comfort through the artefacts, which go beyond its functional level and address psychological and social aspects of use and consideration.

“Finding the Right Position”: Balancing Comfort and Convenience, Contextual Constraints, Habits, and Object Affordances

The previous user study, which had looked at the usability of existing personal thermal devices (chapter 5), already established that participants would test and use personal thermal devices on different body locations independent of the assigned usage location but based on perceived and relational affordances. However, the more detailed user feedback collected in this study shed light on the exploration process taking place in finding the right location and position to use a heating prototype in and the aspects underlying and affecting people’s exploration of the affordances in their search for the right position, which is not only influenced by considerations in respect to thermal comfort, but comfort per se, taking contextual, physical constraints of the space, habits and the perceived affordances of the object into account.

Although the importance of direct affordances has been pointed out and the direct perception of affordances has been proclaimed as key to the design for usable systems in HCI (Gaver 1991), studies into perceptual learning in infants suggest that exploration plays an important role in forming the cognitive perception of affordances in the first place (Gibson & Pick 2000; Kaptelinin 2016). This includes the physical enacting and manual testing out possible relations between the self and an object, which essentially forms an individual’s understanding of perceived and relational affordances. The reported and documented search for the right position of participants in the scope of this study showed that exploration is an active and important part of making sense of the affordances of new, formerly unknown devices and uncovering the perceived affordances of artefacts beyond the intended ones. The exploration of affordances in respect to a functional thermal device can be considered a search for the optimal solution between eliminating the most pressing source of thermal discomfort and thus improving perceived thermal comfort, ergonomic fit in the physical and habitual context and functional comfort in the activity space. Additional suggestions of body locations to use the

prototype on beyond the ones enacted by two participants, as well as the fact that participants thought it necessary to explain why they did not use the prototype in a specific location, such as was done by participant A9 in respect to its use on the lower back, indicates that participants were aware of additional actual affordances in the prototypes but also an awareness of the constraints.

Even though metaphors were used in the design of the prototypes to ease the perception of affordances in respect to physical and locational use, the study showed a much higher complexity in the perception of affordances in actual use. The relational and perceived affordances of objects for thermal comfort were not only limited by the range of uses and actions the prototypes afforded through their metaphorical design and by contextual constraints including those of the physical environment, such as the relation between body and desk, and the tasks to perform, such as typing, using the mouse or reading as compared to talking to people, but also by individual, psychological constraints in form of habits, such as how to sit on a chair. Furthermore, and most importantly, the use and decision where to use a prototype was determined by individual considerations of comfort and discomfort, personal needs, materiality and form characteristics of the prototype, in short, the individual comfort and convenience of the solution in its contextual setting. In the scope of this decision-making process additional affordances and factors were taken into consideration beyond the main functionality of the prototype, i.e. heating to improve thermal comfort. These included considerations of ergonomics to improve posture and using the warmth not only to alleviate thermal discomfort but also to relieve pain in the lower back.

This finding extends the framework of affordances by Norman (1999), who suggested that constraints and conventions are the sole influencers and limiting aspects of a user's action on affordances. Less consideration was given at that time to individual constraints, such as habits, as well as personal preferences and divergent needs in respect to the same functionality, which would affect perceived affordances and in consequence the use and usability of devices. However, it can be argued that at least the latter parts were previously summarised in what was described 'the goals' (Norman 1998) and that individual, user-specific aspects only gained greater focus in the community with the advent of personal electronic devices.

“Finding Comfort”: Transcending Need towards Psychological Comfort, Emotional Design and User Experience

As could be observed in the feedback given by participants in respect to their associations towards the respective prototypes but also in their reasoning in respect to preferred prototype and prototype use, the achievement of comfort through a personal thermal device goes beyond the mere functional aspect of providing warmth and the design for usability. On a small scale, it could be observed that the relationship between user and device transcended the comfort layers described by Vischer (2008) (see chapter 2), in particular the functional and psychological

layers. The underlying structure of the experience, the meanings and values outside the direct context of the problem encompassed the quest for comfort beyond the merely physiological state towards comfort as a state of mind (Shove 2003). However, it has been argued that while striving to satisfy their needs, the focus of individuals in doing so naturally transcends different levels in the hierarchy (van der Bijl-Brouwer & Dorst 2017). It moves from one to the next and between levels depending on the acuteness of the need, but in general upwards in the hierarchy (McLeod 2018; Duval et al. 2010).

In consequence, cases, in which thermal discomfort was the predominant factor in the experience of participants, the form and functionality of the prototype, i.e. which area and which location of the body it could cover, the amount of heat and the flexibility in use it provided and thus how well it helped to alleviate individual thermal discomfort, was decisive for preferred use and satisfaction with a prototype. The majority of participants expressed a preference for the wearable prototype stating one or several of these points as reasons for their choice. Only participant A4 experienced a discrepancy between her use of the wearable prototype to satisfy functional comfort needs and her actual preference for the portable prototype to satisfy psychological and emotional needs. This is in line with the emotional design proclaimed by Norman (2004) having to be taken into consideration in the relationship between the user and the artefact, which in software design is considered the user experience of the system (Hassenzahl & Tractinsky 2006). Therefore, the design of objects happens on several layers, so designing successful objects is not only about catering for appearances, the visceral level, and for functionality and usability, the behavioural level, but also for the reflective level, which touches upon people's memories, contributes to their personal self-image and satisfaction, and addresses emotional needs (Norman 2004). The design of the portable prototype used in this study accordingly evoked responses situated at the reflective level contributing to psychological comfort. Their interaction with the prototype reminded participants of how they would interact with a pet, such as a little dog or cat. Similarly, it was described as an anti-stress and relaxation device, the touch and interaction with which helped relax the mind and supported creativity.

The study showed that users actively considered, balanced and appreciated these different aspects of design, but also that they choose and reason their preference in relationship to their most dominant need. It also showed that the reflective layer of design is indeed dependent on the individual and therefore more or less pronounced in the relationship of a person and a specific artefact. Furthermore, the statement of participant A10 explaining the differences of the prototypes in their ability to make him warm versus make him comfortable shows the close relationship between emotional design and design for (thermal) comfort, which merged in the design for a wearable/portable personal device.

From Use to Acceptance and Adoption: Addressing Social Experience, Fashion and Self-Image

Unlike Norman (2004) argued, namely, that the emotional aspect of a design is more important than its function, participants in this study chose and reasoned their preference for a prototype rather in respect to the function than the emotional aspects associated with it. A real need for a functionality overlaid the emotional need, which essentially means that the trade-offs considered were more pronounced in favour of functionality over emotion. Considering the setting of prototype use as part of a user study, however, these findings cannot necessarily be taken as indicators for future acceptance and adoption of a potential product. Reflective aspects not so far discussed and not so prominently reported during the user study have to be considered: self-image in respect to the use of the artefacts in the social context of a shared office and workplace, fashion and possibility of self-expression.

A feeling of awkwardness was reported concerning the use of the wearable prototype, as participants were afraid that wearing it would draw attention of their co-workers. Inferring from the suggestion to improve the aesthetic appearance of the prototype, the feeling of awkwardness was rooted in its inelegant appearance as a 'black cloth' in combination with its high visibility when worn around the shoulders. How the interpretation of aesthetic qualities of a wearable by others is perceived by a user is key to so-called aesthetic wearability and affects the user's acceptance of the product (L. E. Dunne et al. 2014). In general, wearable devices have been found to transcend models of acceptance for technological systems, behaviour change and fashion trends, thus adding aesthetic and emotional values and aspects of self-image, which are related to the user experience, to a more functional mix, such as perceived usefulness and ease-of-use (L. Dunne et al. 2014). In consequence, the design of a wearable along a metaphor, although clearly supporting usefulness and appropriation for comfort, also requires visceral and reflective aspects of the original metaphor to be met. In the case of the wearable prototype the metaphor related to scarfs or shawls, which constitute fashion accessories. Attached are expectations of colours, patterns and cuts, which allow for personal expression and support identity.

In correspondence to this, customisations have been proposed by participants to improve the expression of self through the prototype and to improve prospects of long-term adoption of the devices. Suggestions ranged from the customisation of size, shape and colour of the artefact according to individual preferences to a completely modular approach, which detaches the functional layer from the expressive layer or carrier. If the adoption of wearable devices, especially concerning artefacts subject to trends, such as clothing and textile accessories, should be improved, either customisation or a modular approach providing flexibility in the carrier layer need to be addressed in future.

7.5 Summary

This user study studied the achievement of comfort through the use of two personal heating prototypes with different inherent affordances and properties. It was found that comfort was achieved by balancing individual needs, perceived comfort, context of use and convenience, but also individual, personal constraints, such as habits, and that comfort in the use of the artefacts transcended from a pure functional need to a psychological state. Furthermore, it was found that the preference of people was determined based on the acuteness of needs in question, which saw shifts of and varying individual foci on a spectrum between functional considerations and emotional, reflective aspects. Finally, the importance and impact of aesthetic and emotional aspects, such as self-image and social acceptance, in respect to the acceptance and adoption of wearable devices was discussed and how to address in design through customisation and a modular approach.

Chapter 8

Studying Trade-Offs in Manual vs. Automated Control for Personal Cooling

This chapter presents the development of a wearable personal cooling prototype to assist the closer investigation of partly autonomous systems in wearable thermal devices. As discussed in chapter 2.2.5, previous research has established the application of smart automated control in combination with PEC and wearable systems as an area of further investigation (Vesely et al. 2017; Udayraj et al. 2018). Automated control might be able to balance the negative effects of having to exercise control too often manually on satisfaction and productivity levels (Paciuk 1990). By offering an active smart control setting, participants could delegate temperature adaptation to the device. However, by delegating control to the device, participants would also be trading parts of their autonomy over their thermal comfort for convenience. Furthermore, safe control of device functions in smart wearable systems has found to be one concern of potential users (Duval et al. 2010). In consequence, this study set out to explore the acceptance of a smart wearable cooling device and to explore the trade-offs involved and decisions taken in favour of autonomy versus convenience or vice versa. To this end a basic manual control mode was compared with a simple adaptive cooling mode, which responded to changing environmental conditions.

8.1 Methodology

The development of the prototype employed in this study was based on participants' requests in previous studies (chapter 5, 6 and 7) for 'smart' control, i.e. for a device that would automatically adapt to environmental conditions. Although in previous studies (chapters 5 and 6) a preference for off-body convective cooling was observed, a conscious decision for the development and deployment of wearable cooling system was taken. The development was inspired by other similar developments in the field, such as the cooling glove (Cooling Glove ME 2013; Grahn et al. 2009) and early prototypes of the Embr Wave (Embr Labs 2018), with the underlying intention to study smart control close to the body to confirm or disprove concerns expressed related to this found in earlier studies (Duval et al. 2010). In preparation of

the study and during the development of the prototype further considerations revolved around the control interface and its representation of temperature values, as well as the approach to control that would result from it. This question had originally surfaced and been critically reflected on by participants in the low-fidelity study (see chapter 6), in which participants had been given the choice between controlling the temperature of the low-fidelity heating/cooling prototype on the device represented as an analogue scale or using a smartphone app allowing to input temperature in precise degrees. The representation affected whether participants would control the device based on the sensory perception of the cooling effect or due to their cognitive evaluation of the set temperature. Previous research found that different representations in temperature control and different designs of control interfaces affect the mental model of users in respect to the system and in turn their behaviour and control strategies (Revell & Stanton 2018). As the design and study of control interfaces would have constituted a considerable shift in the focus of the research, a decision was taken to continue the use of an analogue scale for temperature control. The analogue scale supported experiential perception of temperature and allowed to focus on aspects related to smart automated on-body control, which would be of relevance to the future development of wearable personal thermal devices.

8.1.1 Prototype

To study the perception and acceptance of smart control, a personal cooling prototype was developed, which allowed to run two different control modes: a manual setting, which decreased the temperature of the device upon user input, and an adaptive setting, which adjusted the device temperature based on ambient conditions. In the adaptive mode, the user manually selected a reference temperature, based on which the device reacted to changes in the ambient conditions. If a change in ambient temperature was recorded, the temperature of the surface of the Peltier would increase or decrease accordingly to lessen the impact of the increase of the temperature difference between the ambient temperature and the surface temperature of the Peltier element. A switch allowed to change device behaviour from a passive to an active smart wearable device (see chapter 2.2.1).

The microcontroller circuit of the cooling prototype featured an ATtiny85¹ microchip, which controlled the strength of the cooling provided by a Peltier² element. The electronic circuit was thus constructed that the cooling circuit could be run off a 12V/2A battery. A sensing circuit was included in the prototype's circuit to monitor the temperature outside the device when in use and serving as input for the adaptive mode (Figure 8.1). An XBee Series 1 allowed to send information on the device mode, the temperature setting and ambient

¹ ATtiny85-20PU, 8bit AVR Microcontroller, <https://uk.rs-online.com/web/p/microcontrollers/6962327/>

² Peltier elements are thermoelectric modules, which produce a temperature difference between two plates if a voltage is applied. Heat is removed from one plate, so cooling occurs, and is transferred to the other plate, which results in the second plate heating up.

temperature to the base station of the sensor network. The arrangement of the electronic circuit inside of the wrap of the prototype is depicted in Figure 8.1.

The prototype was designed as a wearable device using a textile cover for ice packs as a base. The cover was equipped with a Velcro strap, which meant that it could be wrapped and fastened around the extremities (Figure 8.2). In the inner lining of the cover a 40mm by 40mm Peltier element was placed, which provided an adjustable cooling surface. The excess heat created by the Peltier element was transported off using a heat sink and a fan, which were fastened on the outside of the textile cover. The hot surface of the Peltier element was attached to the heat sink and fan, whereas the cool surface was facing the inner lining of the textile pad. The cooling surface of the Peltier was covered with a silver textile, which prevented the Peltier to have direct contact with the skin but at the same time would not provide too strong insulation. The Peltier circuit was stored inside the textile cover. A knob on the top of the cover allowed to control the temperature. A temperature sensor placed at the outer surface of the wrap monitored the ambient temperature. The switch to change between the settings was hidden inside the pad on the circuit board.

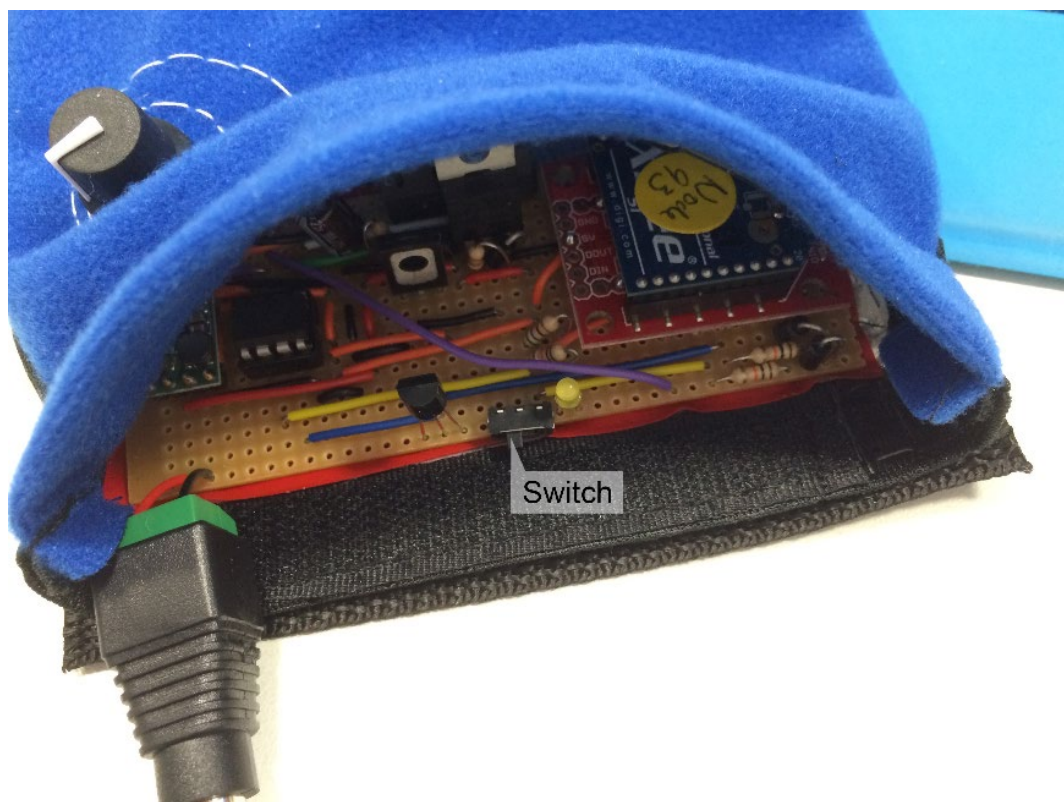


Figure 8.1: Personal cooling prototype including sensor circuit.

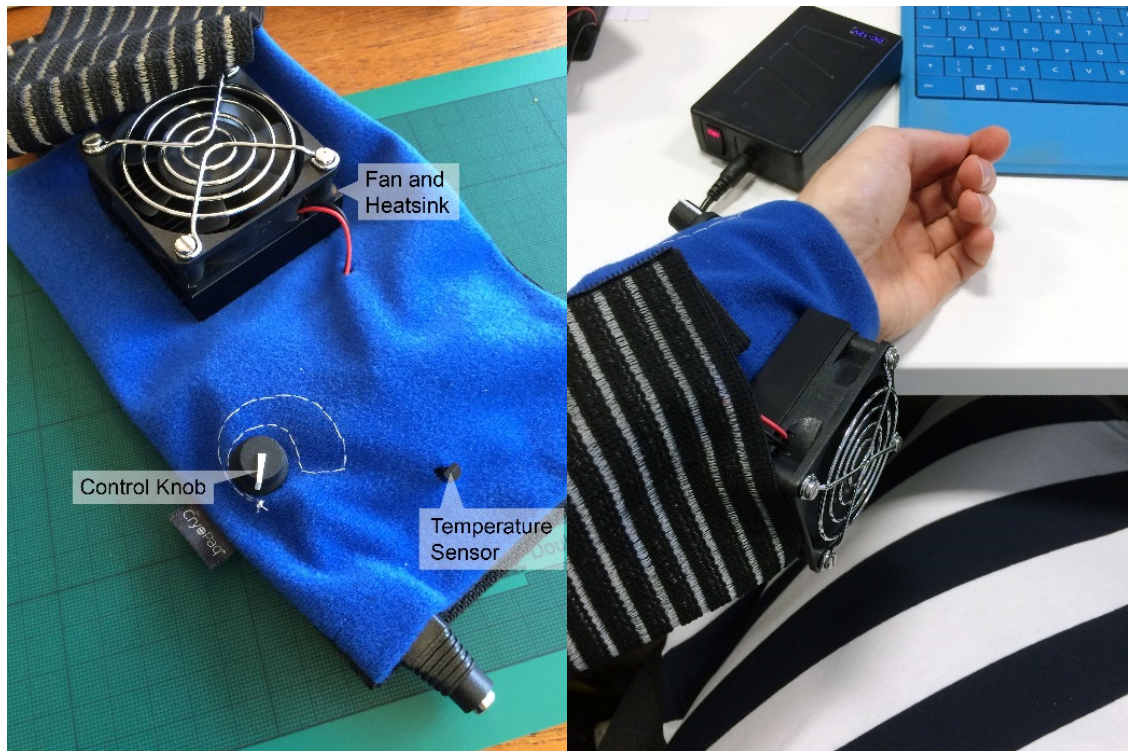


Figure 8.2: Personal cooling prototype with fan and heat sink, control knob for temperature control and temperature sensor (left). Personal cooling prototype wrapped around the wrist (right).

8.1.2 Study Set-Up

The study was laid out in the same way as the study on affordances of personal heating devices. First, the overall conditions and general comfort of participants in their workplace was assessed using an IEQ questionnaire. In addition, sensor nodes were installed at their workplace and stayed installed throughout the study. Next, a cooling prototype starting in one of the two control modes was given to participants and participants were instructed on how the prototype worked and how the temperature was controlled. In addition, they were given health and safety instructions, which included to not use the device if they felt uncomfortable using it and to report any issues to the researcher. Participants had the device at their disposal for two working days after which the control condition was changed and the personal cooling prototype made available for another two days.

On each day of the study, participants were asked to fill out right-now questionnaires up to four times a day. At the end of the test period for a condition, we asked participants to reflect on their use of and satisfaction with the device and its control and to fill out a brief evaluation questionnaire. The evaluation questionnaire asked participants to rate their satisfaction with different usability related aspects and included the comfort rating scale originally developed by Knight et al. (2002) to assess wearable devices in the adjusted format proposed by Bodine and Gemperle (2003).

To conclude the study, participants were given the cooling prototype for another two working days during which they were able to choose in between both control settings freely using the switch that was hidden inside the wrap. This no-choice/choice approach was used again to find out which of the two control modes users preferred and which trade-offs they considered in their choice (Siegler & Lemaire 1997; Walsh & Anderson 2009; Brumby et al. 2011). After the two working days with both control conditions available, a brief interview was conducted about their use of and experiences with the prototype. The interview was video recorded and subsequently transcribed and analysed.

8.1.3 Participants

The evaluation of the acceptance of different control modes in a personal cooling device took place in August to October 2016 over the course of nine weeks. Participants were again recruited by email among PhD students at the School of Electronic Engineering and Computer Science at Queen Mary, University of London. However, in addition to the 10 participants recruited at the school, 2 participants from the Open Data Institute (ODI) joined the user study. The Open Data Institute is an international non-profit organisation focussing on the establishment of open data frameworks and applications with an office located in London Shoreditch. The order of testing the manual and the adaptive control mode was alternated between participants (Table 8.1). The contributions of individual participants are anonymised and attributed in the text by the abbreviations P1 to P12.

Participant	Building	Device 1	Device 2
P1	CS	Manual Control	Adaptive Control
P2	CS	Adaptive Control	Manual Control
P3	CS	Manual Control	Adaptive Control
P4	CS	Adaptive Control	Manual Control
P5	CS	Manual Control	Adaptive Control
P6	CS	Adaptive Control	Manual Control
P7	CS	Manual Control	Adaptive Control
P8	Eng.	Adaptive Control	Manual Control
P9	Eng.	Manual Control	Adaptive Control
P10	ODI	Adaptive Control	Manual Control
P11	ODI	Manual Control	Adaptive Control
P12	CS	Adaptive Control	Manual Control

Table 8.1: Allocation and sequence of testing of the two control modes.

Out of the 12 participants, 7 participants were female and 5 were male. The age of participants ranged from 21 to 37 years of age. The average age of participants was 28 years. All participants worked in shared offices either in the Electronic Engineering or the Computer Science building on campus, or at the Open Data Institute.

8.2 Pilot Study

In preparation of the main study, a pilot study with two participants was carried out to test the prototype and the general study set-up. Unlike the main study, in which participants were given the prototype in manual, adaptive and free choice mode for two days each, these were given participants in the pilot for one day each. Pilot study participants reported that the prototype overheated in the manual mode and got too warm in the adaptive mode. Furthermore, they reported that the cooling surface was not large enough and the cooling barely perceptible. Based on the feedback of pilot participants, the layout of the prototype was reviewed. A different Peltier element with the larger surface area of 40mm by 40mm instead of the original 20mm by 20mm one used during the pilot study was installed (Figure 8.3). This required a larger and stronger heat sink to better dissipate the heat generated by the Peltier element, which increased the size of the prototype (Figure 8.4). Furthermore, the cooling range was restricted further computationally to prevent overheating to occur.

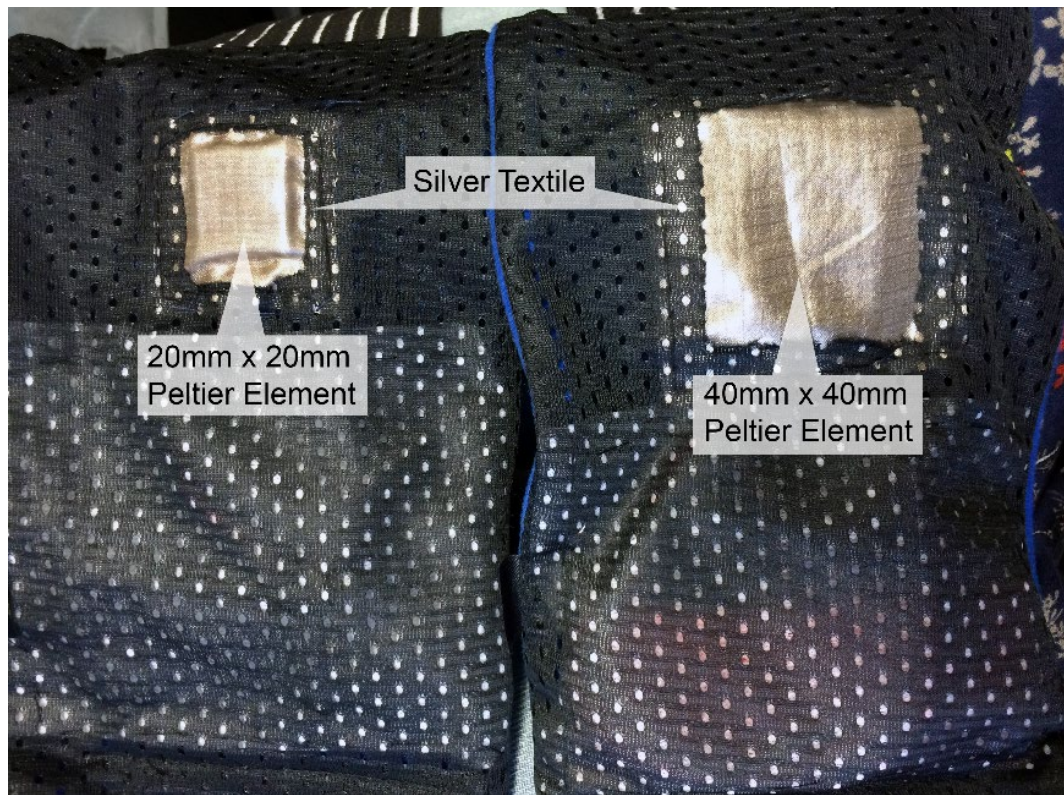


Figure 8.3: The cooling area of the prototype before (left) and after (right) the review of the prototype layout after the pilot study.



Figure 8.4: Cooling prototypes used during pilot study (left) and main study (right).

8.3 Results

This section presents the results of the analysis of the feedback given by participants in the interviews and evaluation questionnaires as well as of the collected sensor data and IEQ surveys. The questionnaires used in this study as well as the complete set of time plots of sensor readings can be found in Appendix E.

The thematic analysis of participant feedback followed a deductive approach centring around aspects related to the acceptance of a smart wearable cooling device and the trade-offs, which would be considered either in favour of autonomy versus convenience or vice versa in decision-taking. Accordingly, interviews and questionnaire responses were first coded and then mapped under the overarching themes of prototype use, which included patterns and locations of use, usability, ease-of-use, wearability and user experience, including further aspects related to attitudes and associations, interference with work, and suggestions for improvement. Furthermore, perceived differences between, experiences with and preferences for the two control modes that were tested by participants were coded and then mapped. In a subsequent step, sub themes were developed and established, which led to the findings presented in the following.

8.3.1 Satisfaction with IEQ and Perceived Thermal Comfort

At the beginning of the study participants were asked to fill in an IEQ survey and questions on their general thermal background to assess their perceived comfort in the workplace as well as any environmental issues affecting it. The satisfaction rating with different IEQ parameters can be seen in Figure 8.5. Participants rated their satisfaction with personal control over the thermal environment and over air quality as the lowest, followed by sound privacy and air quality. The

parameters with the highest satisfaction ratings were the amount of available space and amount of light followed by the ease of interaction with colleagues. Overall participants were slightly satisfied with their workplace. However, they rated the impact of their workplace IEQ on their productivity as slightly negative. The general trends of IEQ satisfaction ratings upheld across studies.

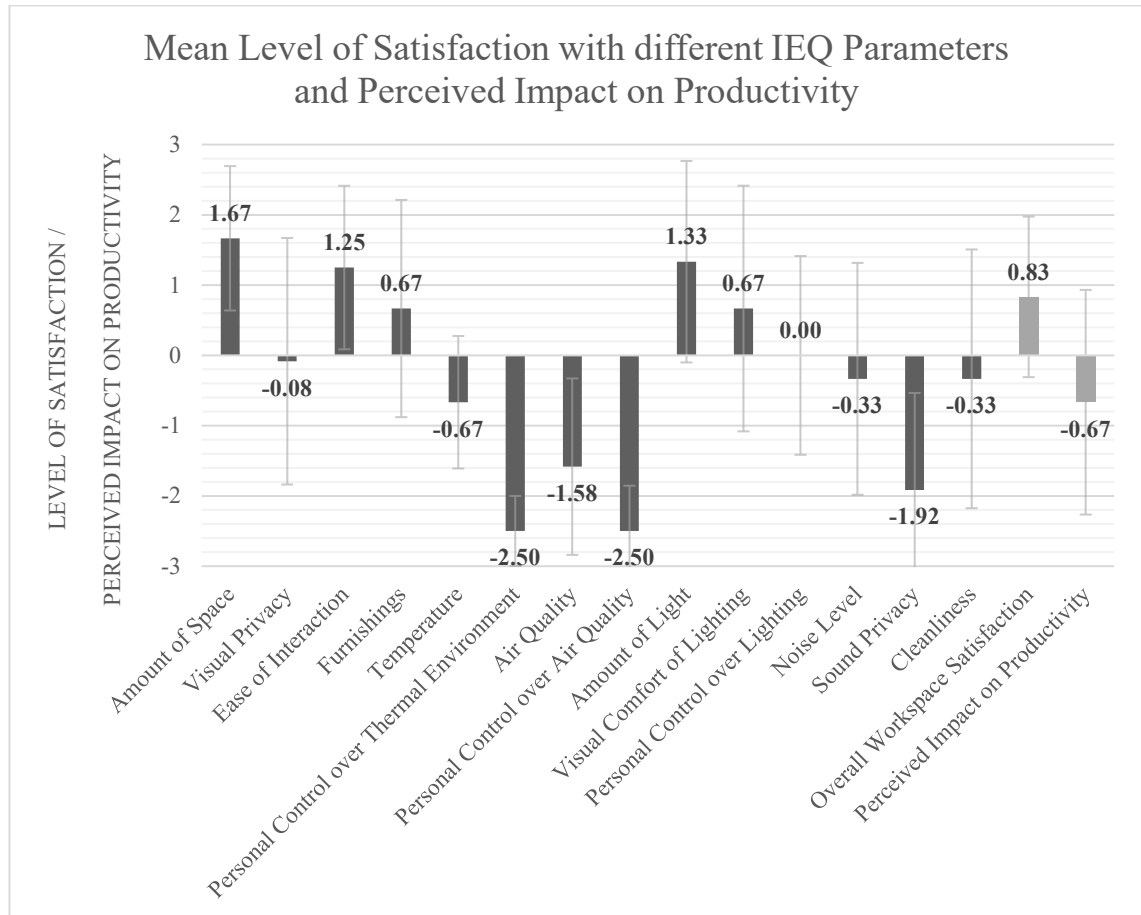


Figure 8.5: Mean satisfaction ratings for different IEQ parameters and the mean perceived impact on productivity.

Asked about their thermal comfort in warm/hot weather, nine participants indicated that their workplace was often too hot. One participant had not experienced a hot period in their office yet. Nine participants reported that the workplace being too warm was most often a problem in the afternoon (2pm – 5pm), five during midday (11am – 2pm), three in the evening after 5pm and one in the morning (before 11am). As the most cited sources of discomfort, ten participants mentioned the air movement being too low, six participants the incoming sun, and two participants each the air movement being too high, draughts from windows, heat from office equipment and hot was surfaces, high humidity and that the heating/cooling system did not respond quickly enough to the thermostat. Asked about how the warm/hot conditions affected them, seven participants reported that their hands were too warm, out of which five said that their feet were also too warm. Out of these five, two participants mentioned that they felt hot in

general and that everything was warm. Other participants reported that it was not comfortable to work, or they needed more air movement but no air conditioning. One participant stated that they felt okay under these conditions.

8.3.2 Reported Behavioural Adjustments and Decisions on Environmental Control

Out of the 12 participants, 4 identified as a person, who feels cold easily, 1 as a person, who feels warm easily, 3 as both, 4 as neither. Asked about their way of adjusting to a hot office environment, six participants stated that they turn on a fan, four that they open a window, and three that they either remove a layer of clothing or wear light clothing (see Figure 8.6). Other measures mentioned include to create air movement, using a folding fan, opening a door, to use air conditioning or to sit close to an air-conditioned room or drink cold water. In general, participants voiced a difficulty to achieve thermal comfort in their work environment but also to express their discomfort to their colleagues. One participant mentioned that they “*suffer in silence*” (P1).

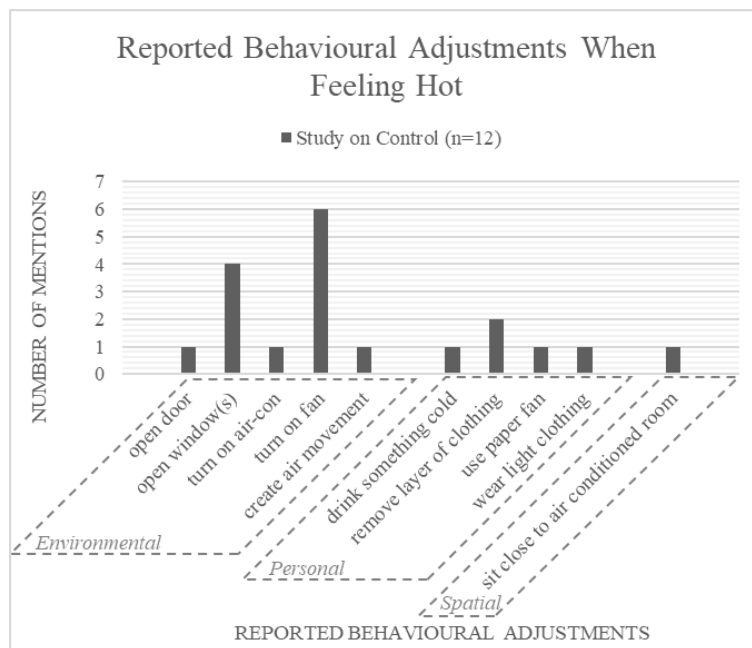


Figure 8.6: Frequency of different self-reported behavioural adjustments when feeling hot (study on control).

Participants were furthermore asked, how the temperature is controlled and who decides. Five participants reported that the temperature is centrally controlled. Three participants reported that the fans are individually controlled by people, two reported the same for heaters. As to the question, who decides, one participant stated that the eldest or pregnant colleagues decide. Other participants stated that whoever comes first in their office decides, whoever is uncomfortable or that generally someone else decides. One participant did not know.

8.3.3 Time Series Plots: Examples of Thermal Comfort and Behavioural Adaptation

The following section describes an individual story of thermal discomforts and behavioural adaptation, as recorded in the right-now surveys and mapped to the collected environmental and device data. The story of participant P2 on three exemplary days during the test period are reported as example. The full set of time series plots of the temperature graphs over time including the qualitative feedback of perceived comfort at certain points in time for each participant can be found in Appendix E.

Participant P2 worked in an open-plan office in the Computer Science building. The major sources of discomfort she reported during the test period were related to the lack of airflow or hot surrounding surfaces. The windows were kept open over the whole test period with the participant occasionally opening the door in addition for cross ventilation. On the second day of testing the cooling prototype in adaptive control mode P2, reported starting from 13.49 that the air movement was too low. The windows were reportedly open all day and P2 opened the door in addition at this point. In the time series plot (Figure 8.7) it can be seen that the temperature at the participant’s workplace was constantly rising over the course of the afternoon. Office windows facing west were responsible for the increase in temperature at this time of day. P2 switched on the cooling prototype in the evening, when the office temperature reached its peak and became unacceptable. Accordingly, the participant reported feeling hot and wanting to be much cooler. She stated at 19.33 that the device was very helpful for lowering the body temperature and made her cool down both physically and emotionally.

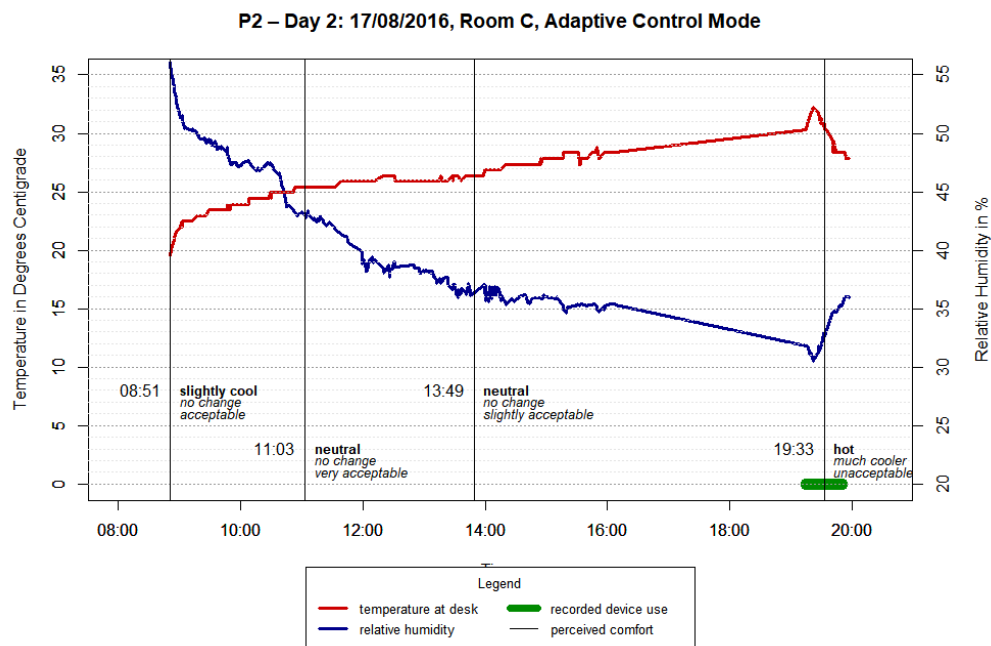


Figure 8.7: Recorded temperature and humidity levels at participant P2’s workplace on the second day of testing the cooling prototype in adaptive control mode.

On the second day of testing the cooling prototype in the manual control mode, participant P2 reported changes in the perception of thermal comfort from neutral at 14.18 to slightly warm but still acceptable at 17.01 to warm with the wish to be a bit cooler at 19:16 (Figure 8.8). Device use was recorded at around 18.00 and once again shortly after. The participant commented at 19.16 that the local cooling effect made her feel cool on the whole-body level, but that when she turned off the device, she would feel hot again. Furthermore, the cooling would at some point be too much and not enjoyable anymore. In respect to the control mode she stated that she found the manual mode easier to control and the cooling to be more effective than in the adaptive mode. However, she suggested to nevertheless add some automation settings to control the switching on and off of the cooling device. Environmental data collection broke down in the early afternoon because the sensor node ran out of battery.

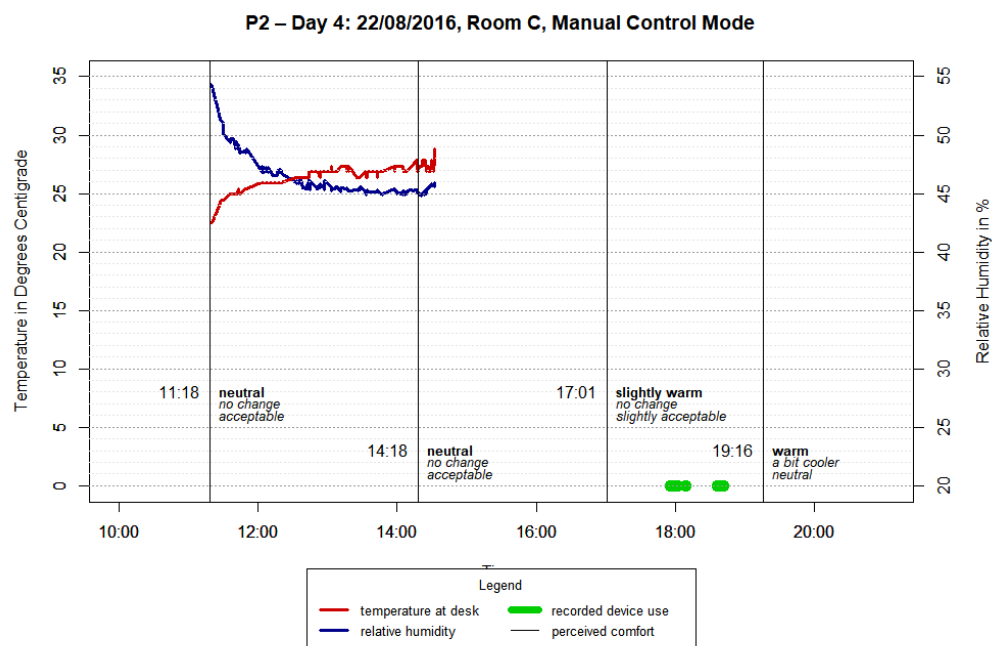


Figure 8.8: Recorded temperature and humidity levels at participant P2's workplace on the second day of testing the cooling prototype in manual control mode.

On the last day of testing, participant P2 used the cooling prototype mainly in the manual mode but reported switching between the modes. At 19.33 she stated using the prototype in adaptive mode when she considered the temperature to be warm, whereas to prefer to control the prototype manually when feeling hot to cool down as fast as possible. Although the state of the windows was reported to be open at all recorded points, the temperature plot in Figure 8.9 shows that the windows were opened and closed at several points in time over the course of the afternoon.

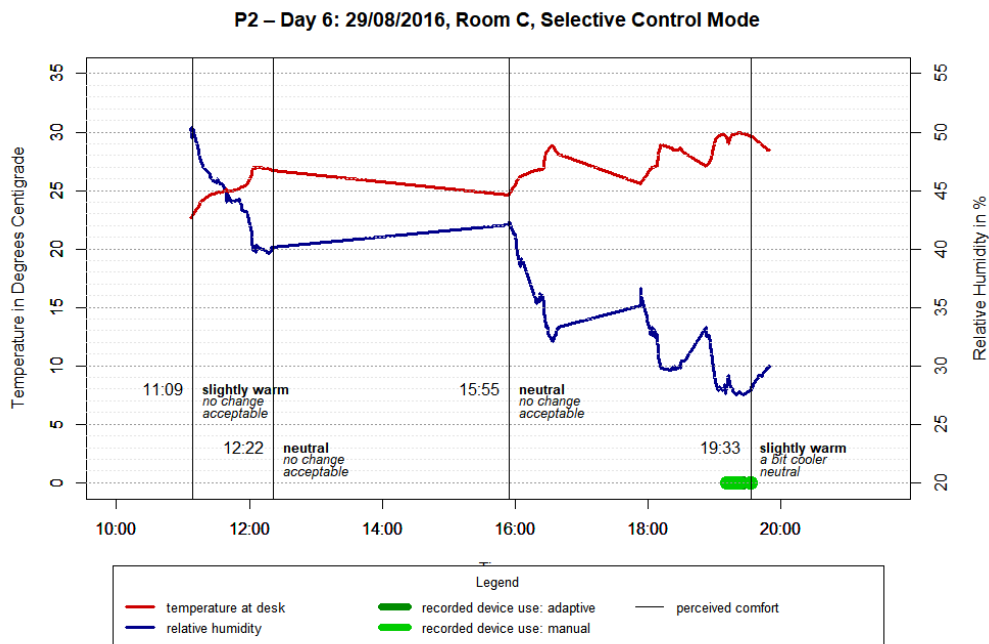


Figure 8.9: Recorded temperature and humidity levels at participant P2’s workplace on the second day of testing the cooling prototype with changing control modes.

8.3.4 Prototype Use, Usability, and User Experience

Participants provided feedback on the prototype in the evaluation questionnaires at the end of the first two episodes and also during the interview session at the end of the study. This subchapter will provide an overview of the results in respect to the general prototype use and the feedback given in respect to its perceived usefulness independent of different control settings.

Reported Patterns of Use

Four participants reported having used the prototype in the afternoon, when the office was becoming stuffy (P2) or hot (P1) or they felt hot after coming back to the office after lunch (P5). Two participants (P3, P9) reported having used it in the morning. In respect to the frequency and duration of prototype use, participants P4 and P12 reported having used it a few times a day, in one case for approximately 10 minutes on each occasion (P12). Another participant reported having used the prototype for 2 hours at the hottest time of day (P8). Participant P7 stated the use of the prototype in 2-hour slots at fixed times during the day: from 9am to 11am, 3pm to 5pm, 5pm to 7pm 11pm to 1am. However, none of this device use was recorded. Five participants related their use of the prototype to feeling warm or hot (P1, P10, P12) or to the environment being warm or hot (P2, P8). Three participants reported making use of the prototype when the office was getting stuffy (P2, P4, P8). Three participants also mentioned using it coming in from the hot outdoors (P5, P6) or after running around (P8). One participant

mentioned using it after sitting for a while (P4), another while programming or writing code (P7).

A cumulative frequency graph of the recorded duration of use for the cooling prototype in adaptive and manual modes can be seen in Figure 8.10. The recorded median value for adaptive control use was 24 minutes in comparison to 19 minutes for manual control. However, the variability of usage times was higher for the manual mode with an interquartile range of 35.75 minutes compared to 25 minutes for the adaptive mode. As was already observed in the study of personal heating devices in chapter 7, individual durations of prototype use varied widely, from short durations of use of 8 or 9 minutes to longer usage durations of 35 (adaptive control) and 45 minutes (manual control) and up to several hours in extreme cases. However, the variability of recorded usage times of prototypes was considerably lower in this study.

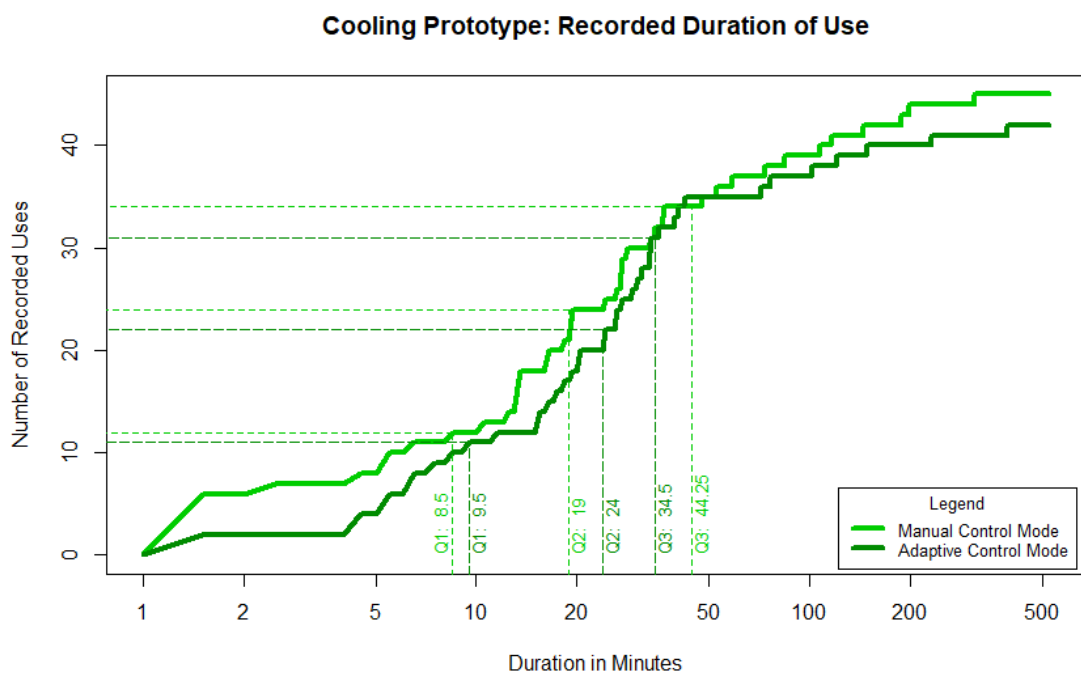


Figure 8.10: Recorded duration of use of the cooling prototype in adaptive and manual mode as cumulative frequency graph.

Locations of Use of the Cooling Prototype

In general, the cooling prototype was designed to be placed around extremities, in particular the arm. However, participants reported appropriating the device and trying the cooling prototype on different other parts of their body as well. Three participants reported trying the prototype on their wrists first (P6, P10, P12). Participant P10 reported that he used it mainly there, as he felt it was *“the easiest way to put it on and get it off quickly and easily”*. However, the other two participants reported that the placement of the prototype on the wrist restricted typing and that they therefore moved it further up the arm. Six participants mentioned using the cooling prototype on their upper arm and another three participants on their forearm or close to the

elbow bent. However, a participant stated that *“it is a bit difficult to choose where to put on my body”* (P5). Four participants reported moving the cooling prototype to other places after first trying it on their arm, either because they found the cable distracting (P1, P4), the position not comfortable or in the way while working or typing (P5, P6) or because the cooling element felt too cold on the bare skin (P4, P8). Participant P8 continued using it on the upper arms on days, he was wearing long sleeves and participant P6 moved the prototype to the left upper arm, so it interfered less with work activities. Otherwise, participants reported moving the cooling prototype to the upper leg, thigh or lap (P4, P5, P8) or the calf (P1). This placement was considered more convenient, as the prototype or the cabling and battery (P1) did not get in the way and the skin felt less sensitive to the cold (P8). Two other participants (P2, P3) also reported using the cooling prototype on their upper leg, with participant P3 reporting that it was too cold in this position and that she moved it to sit on the table next to her instead.

Three participants reported keeping the prototype on the table, mainly because the surface was perceived as too cold to be kept on the body (P3, P9). Two of these participants (P2, P3) mentioned putting their hands on the prototype every now and then in this position and two (P3, P9) taking advantage of the cooling but also the airflow created by the fan to *“cool down the area around me”* (P9). The fan was also taken advantage of by participant P8, who reported that on a particular hot day, he placed and regulated the cooling prototype in a way that *“it would blow down the leg, so that it would cool down the entire leg instead of just that zone”* (P8). However, the participant also stated that the fan was the major confounding factor and he had to stop using the prototype, as the fan provided too much cooling.

Prototype Usability, Ease of Use, and Comfort of Wear

In the study evaluation questionnaire, participants were asked to rate their satisfaction with different aspects of usability and usefulness in regard to the cooling prototype as well as how much their feeling of control and the perceived thermal comfort was increased or decreased during the use of the prototype. Figure 8.11 gives an overview of the mean ratings received by participants. As can be seen, both the feeling of control as well as the perceived thermal comfort slightly increased with prototype availability. The amount of cooling the prototype provided showed the highest satisfaction rating, alongside the temperature control and the appropriateness in context, whereas the portability as well as the comfort of wear were the aspects participants were least satisfied with.

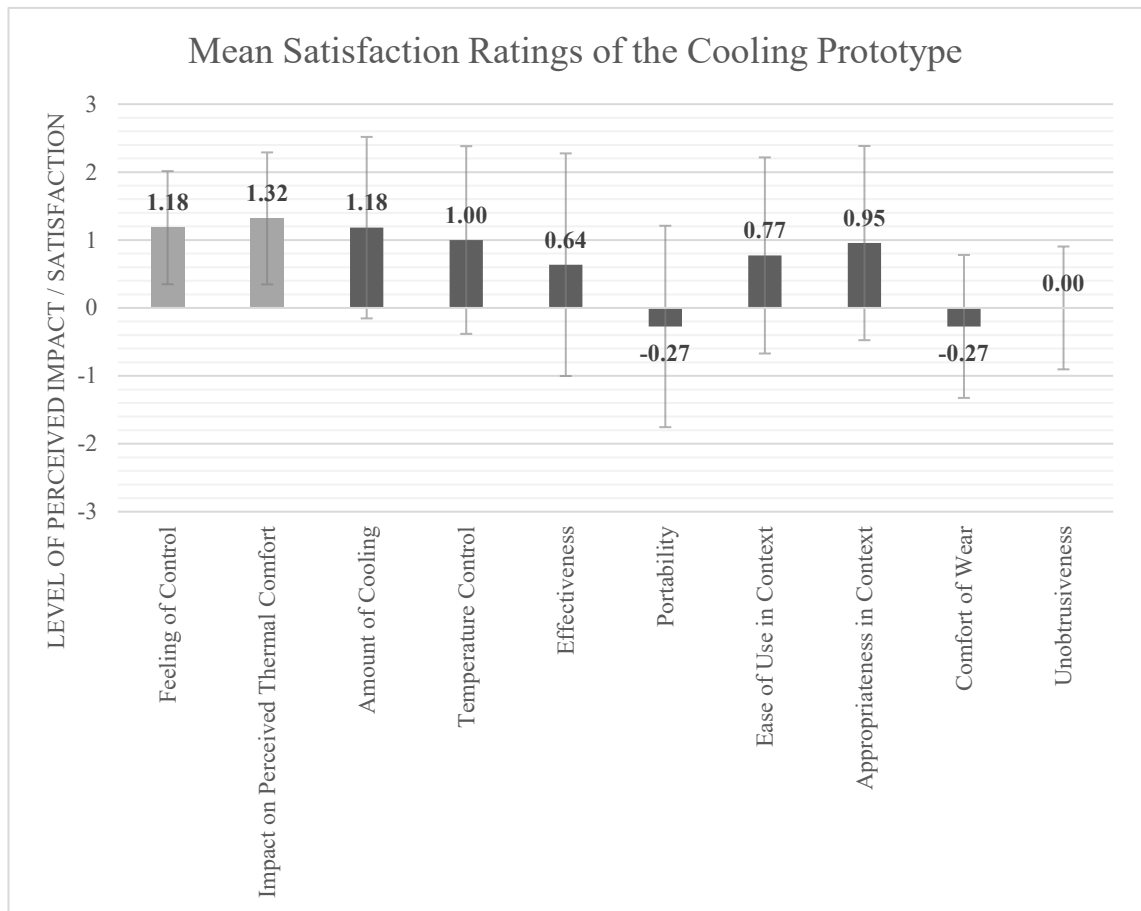


Figure 8.11: Mean satisfaction ratings of prototype usability aspects.

Participants mentioned the following benefits in respect to the prototype: the control it provided, its effectiveness and ease of use, its usefulness and flexibility of use, as well as the positive effects on personal comfort. In accordance with the satisfaction ratings, the control the cooling prototype provided was given as a major benefit with nine out of twelve participants addressing it explicitly in the respective questionnaire section. Participants mentioned that the cooling was "quite effective" (P12), as "the cooling effect was instant" (P1) and "it cools very quick" (P10). They also commented on the usefulness of the device, which allowed them to feel cooler when warm (P7). Other participants commented that it was easy to feel the temperature difference (P2) and the cold through the fabric (P6).

Eight participants commented positively on the control the prototype provided them with mentioning feeling much more in control (P4, P8, P12) and being able to adjust the temperature and amount of cooling (P1, P6, P9, P11, P12). Three participants reported that the control interface was easy to use (P1, P8, P9) stating that it had an "easy mapping between the control and its effect" (P8). One participant commented positively that the temperature could be adjusted while wearing the device and not to have to remove it to do so (P1). Another participant liked the rotary knob as a control interface stating that it was "a cool way to adjust the temperature" (P12).

The flexibility of the prototype to be worn in the preferred location was named as an advantage by one participant (P1). Participant P6 mentioned the fact that it did not get in the way as a benefit of wearing it on the top of the arm. One participant commented that the cooling prototype was useful in hot weather (P2). Participants also addressed the positive effects the prototype had on their personal comfort and work performance, as it "*aided concentration levels*" (P11), helped to "*clear my mind and concentrate on my work*" (P2) when hot and dizzy, and to make "*working easier if working environment is warm*" (P7).

However, participants reported several issues with the prototype, which inhibited its usability, ease of use and comfort of wear as well as its effectiveness. Issues reported by participants included the physical properties of the prototype, its weight and size, as well as its material and fit. The cooling prototype was described as "*bulky*" (P10), "*too big*" (P7) and "*quite heavy*" (P8), while at the same time it was too small for placing it around extremities, such as the lower leg (P5). Participant P5 reported that she could not move very easily with the prototype and had to take it down when leaving the office to go to a meeting or getting something to drink. The weight of the fan element was described as problematic, because it caused the prototype to slide down a participant's calf if it was not properly fixed (P1). Another participant reported issues with the fit of the prototype around her arm, which caused difficulties in keeping the skin contact with the cooling element (P6). In general, participants reported that it was difficult to maintain skin contact for the best cooling experience and that it took some time to adjust the straps accordingly to keep the cooling element in place (P1). The material and Velcro straps of the prototype affected the comfort of wear. The felt-like cover of the material caused participants to feel warm (P5), whereas the Velcro was described as itchy on the skin (P6). In general, the way of attaching the prototype was considered uncomfortable (P7) and it was stated that it was not easy to wear (P11). The fan and the belt were considered too big and awkward, which made the prototype difficult to attach (P7). Another participant reported that the Velcro ruined her stockings during the testing of the prototype (P2).

Two participants mentioned the cabling and power supply as inhibiting factors, as the cable was too short (P6), the battery pack was getting in the way (P6), restricted movement (P2) and they were afraid that the battery would drag the device down (P2). One participant also reported not having been able to use the prototype over a period of time because they kept forgetting to charge it (P3). Furthermore, participants reported issues with the cooling, which was described as too localised, too strong, and too small in the surface area covered. Participants also experienced quick adaptation to the temperature. Issues with the localised cooling effect were reported by four participants. They described it as not effective or even counter-productive (P8), only affecting the area it was placed on (P12) and not cooling off the whole body and therefore not solving the problem (P9). It was perceived as uncomfortable and created a contrast in the perception of temperature (P9). Participant P8 felt the localised effect disturbing and stated:

“When you’re hot, you’re hot everywhere usually. You’re not just hot somewhere and having a small patch sometimes it’s actually quite disturbing, because you’re really hot and you have that patch somewhere which is freezing after a while, so it’s kind of weird. I don’t really know what to think about it.” (P8)

Several participants found the strength of the cooling too much. Participant P12 noted that even on the lowest prototype setting, the prototype was too cold on the days it was used. For participant P8 the fan was the major confounding factor, as it provided more cooling than the Peltier element. Three participants reported getting used to the cooling effect quickly and that they could not feel the cold anymore. Participant P10 stated that it took about 10 to 15 minutes to get used to the cooling. He described it as follows:

“almost like a numbing feeling where you can feel yourself cooling down but then you don’t feel the actual cold on your wrist” (P10).

In consequence, one participant only found the prototype useful in the beginning (P5), another participant kept adjusting the position by moving or turning the prototype (P2), whereas participant P6 reported that the cooling was barely noticeable when wearing long sleeves. One participant struggled with finding the right setting and understanding the temperature mapping:

“I realised I hadn’t really paid attention and then I had to work out which way was colder, cause I don’t know if that’s me being really simple, but I wasn’t sure if ‘low’ was less cold, that looks like more cold? [...] Because you’re trying to increase something that is a negative. Anyways, I spent a little while playing to work out actually what was up, what was down. What does ‘up’ mean if it’s concerning the cold?” (P4)

One participant commented on the inherent contradiction in the control of the prototype, which meant that increasing the temperature setting of the prototype increased the excess heat of the Peltier and essentially meant that the cooling effect of the Peltier was offset by the warm air being blown away from the heat sink (P8). He therefore concluded that the prototype only works on a mild setting.

Participants also reported issues in respect to experiencing discomfort, in form of physical discomfort and noise, as well as social discomfort in form of feeling awkward wearing it. Five participants reported experienced discomforts using the prototype, either because the cooling became painful after a while (P3) or was too strong (P4), the way it was attached was uncomfortable (P7) or the location it was placed in inhibited their work activities (P5), or because the air generated by the fan dried out their contact lenses (P11). The noise of the fan was mentioned by three participants (P2, P3, P4) as an inhibiting factor. One participant reported that she stopped using it because her co-worker was in one day (P1). The participant P1 mentioned that it was a bit awkward and that she was afraid of potentially receiving *“curious looks”*. Also, she did not feel like having to explain what was making noise, which would draw attention to the prototype. Another participant reported that it was awkward wearing the prototype in meetings, as it was quite big, and that she had to take it down (P10).

One participant mentioned that the functionality of the device was off-point and not useful, as temperature was not actually her most pressing comfort issue, but it was the stuffiness and lack of air movement in her office (P8):

“I’m generally happy with the temperature in the room, so I’m not in desperate need for cooling. I’m in desperate need for fresh air, which that thing can’t bring. It can’t provide fresh air.” (P8)

Wearability of the Prototype and its User Experience

The rating of the six aspects of wearability by participants can be seen in Figure 8.12. Participants were asked to rate their agreement with the statements given on a rating scale from 1 to 10. Participants reported a mean level of agreement below average for feeling self-conscious wearing the device (3.50), experiencing pain or discomfort (3.41) and feeling awkward or different (3.27). They rated feeling the device move on their body (5.29) and affecting their movement (5.59) around average. However, their rating of feeling secure (6.0) was slightly higher than average.

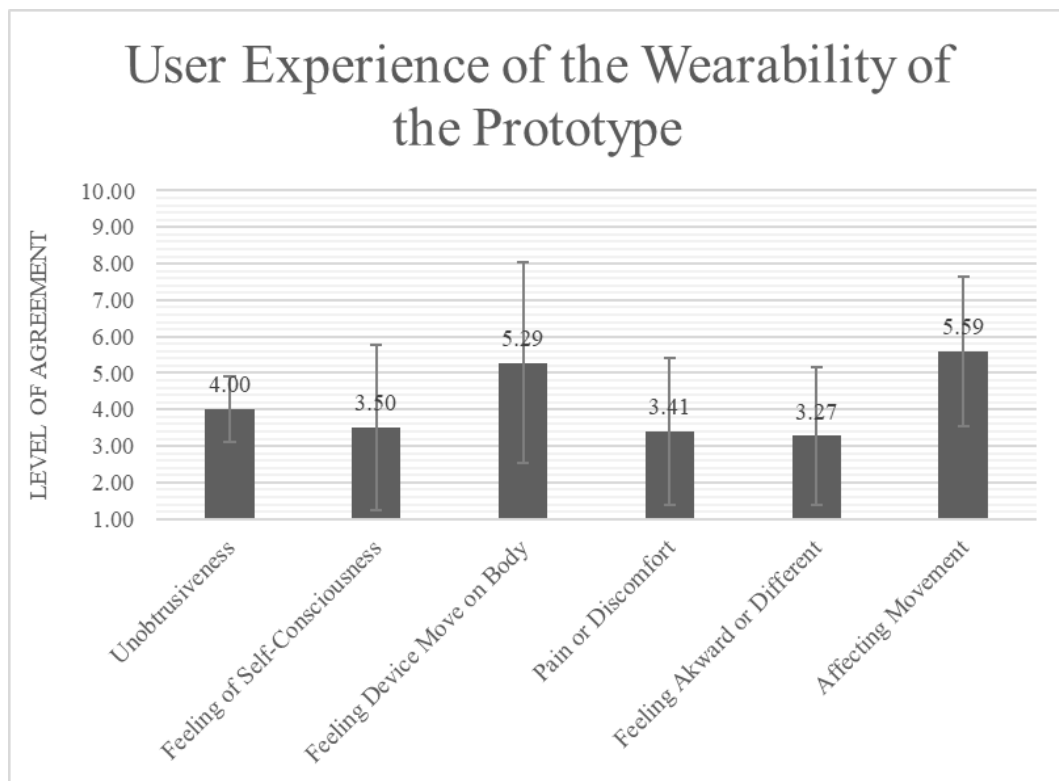


Figure 8.12: Mean rating of different aspects in respect to the user experience.

The agreement ratings split between ratings after the first and second episode show that that the mean feeling of self-consciousness and of feeling awkward decreased in the second episode, as participants became used to the prototype (Figure 8.13).

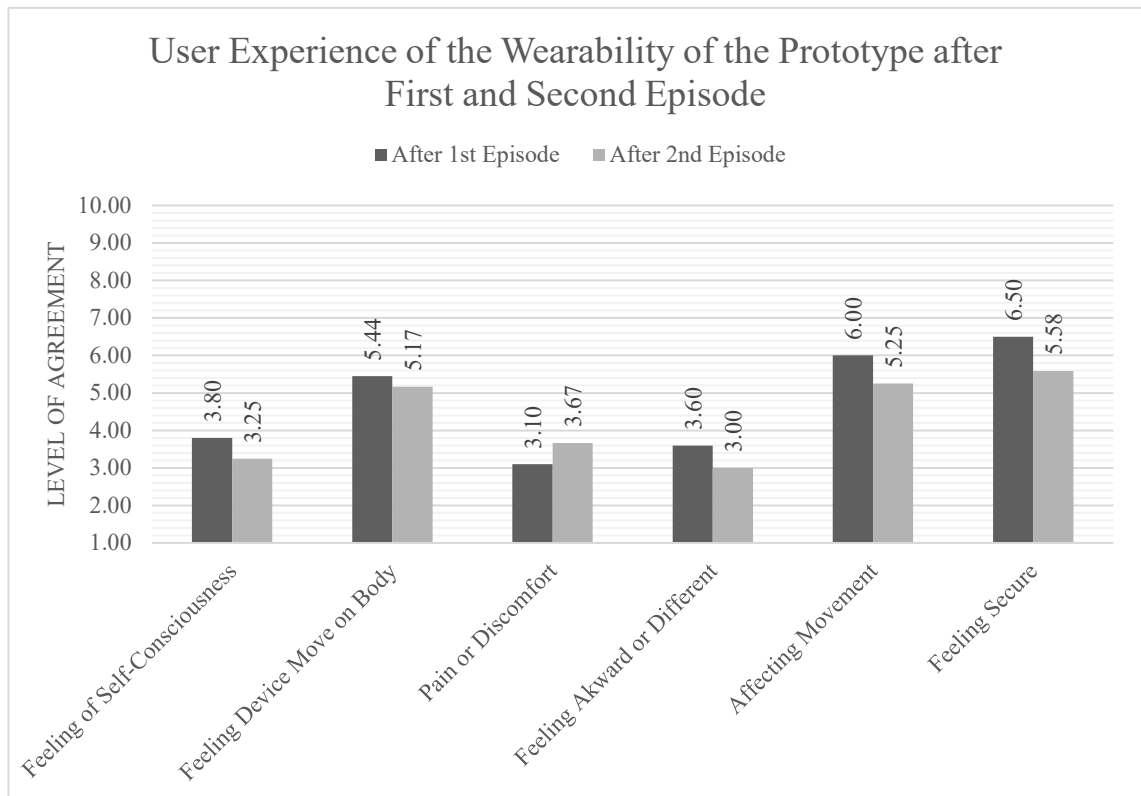


Figure 8.13: Comparison of mean ratings for user experience of the wearability of the prototype after first and second episode.

Attitudes and Associations towards the Cooling Prototype

Participants described the cooling prototype as a means to cool down (P6, P7, P10, P12), freshen and wake up (P4), clear their mind and concentrate (P2, P11) and to help feel relaxed (P7). One participant mentioned that they forgot they were wearing the prototype at all (P5). Participants appreciated the fact that the device was personal (P1) and more discreet (P6) and that it was not affecting other people. However, participant P9 stated that they would prefer something that was off their body. Other participants also stated that although distracting, affecting others and causing draughts, they did like the airflow shared fans in the office provided (P1, P7) or admitted to opening windows for airflow during the study (P4, P8). One participant mentioned that the cooling device could help bring body temperature down especially for women at specific times in their menstrual cycle or during menopause, as well as generally for everyone in stressful situations, like a job interview, in which the body temperature is set to rise (P12).

Interference with Work

In respect to prototype properties interfering with their work, the noise of the cooling fan was the issue most often mentioned (P2, P3, P4). Participants mentioned that finding the right position was key to not interfering with work-related activities such as typing (P4, P6, P12). The

battery pack limited the mobility of participants and interfered with movements at the desk (P2, P5, P6) or when needing to get up (P5). Participants also experienced interference with meetings due to the device's conspicuousness (P10) and discomfort through the air movement provided by the fan when wearing contact lenses (P11).

Suggestions for Improvement for the Cooling Prototype

In accordance with the issues and limitations reported by participants after their use of the cooling prototype, suggestions for improvement included aspects of physical form, such as reducing the size of the prototype and battery, functionality and effectiveness, by increasing the cooling area and the control range, as well as sustainability in respect to the power supply used. Five participants suggested to make the prototype smaller (P7, P10) and to reduce the weight (P1, P3), for example, "*small as a watch*" (P7), and "*more slimline*" (P10) or "*compact*" (P12), as this would support more frequent use and adoption (P7) and easier attachment (P1). One participant stated:

"It would be really good if it was small enough to have [...] on the wrist and you could still type and work" (P12)

In respect to changes of the physical form, longer straps were suggested (P4), so the prototype could be fastened around the thigh. In general, it was suggested to improve the ease of wear (P11) without mentioning particulars but also to have a more customised fit to cater for different body forms and sizes (P6) and custom colours (P1). Furthermore, one participant suggested a hybrid device, which could be both wearable and portable, for example, to be placed on the desk and available for touch (P3).

A smaller battery, a different way of placing the battery (P11) and a different, more sustainable approach to the power supply was also addressed as necessary improvements (P2). It was suggested to use a solar battery (P2), which could charge itself while not in use. Six participants wished for a larger cooling area despite wishes for a smaller size. Four participants suggested alterations to the device to achieve this, such as to spread the cooling pad out (P4), to have a larger surface (P3, P10) or to embed cooling components in the whole belt (P2). Three participants proposed to change the form, either by having something that could be covering the whole room or be like a blanket (P7), or be like a jacket or shirt, which would cover a larger part of the body (P8, P9). In consequence, participant P8 suggested to use an e-textile approach:

"I don't know how practically feasible that is, it's probably very expensive to get one, but that would make more sense to me, because the localised thing is good as a proof of concept, but I don't think it can scale because when you're hot, you're not just hot there." (P8)

Alternatively, they suggested to have several cooling patches in key locations on the body (P8) or something used off-body like a fan (P9) to overcome the too localised cooling effect.

Two participants mentioned having a wider range of control (P3), in particular a colder setting without the device getting too hot in turn (P10), as the available settings were perceived to be limited. One participant wished for an extended adaptive mode, in which the device would cool for a bit and then depending on the ambient temperature automatically switch off (P2). Another participant wished for the device to provide feedback on how the cooling affected one's temperature, as it would increase the sense of control:

“Even if it didn't affect the way it worked, you would still have some idea of controlling your own thermal comfort and having control of your own environment.”
(P12)

8.3.5 Evaluation of Control Modes and Comparison between Manual and Ambient Control

This subchapter will give an overview of the feedback received by participants on the control provided and the perceived benefits, short comings and differences of the manual in comparison to the adaptive control setting tested during this study. One participant stated that the advantage of the cooling prototype was *"having a sense of being able to affect your local thermal environment"* (P12). In general, participants reported a positive effect on their feeling of control and perceived thermal comfort, both of which they rated as slightly increased (Figure 8.14).

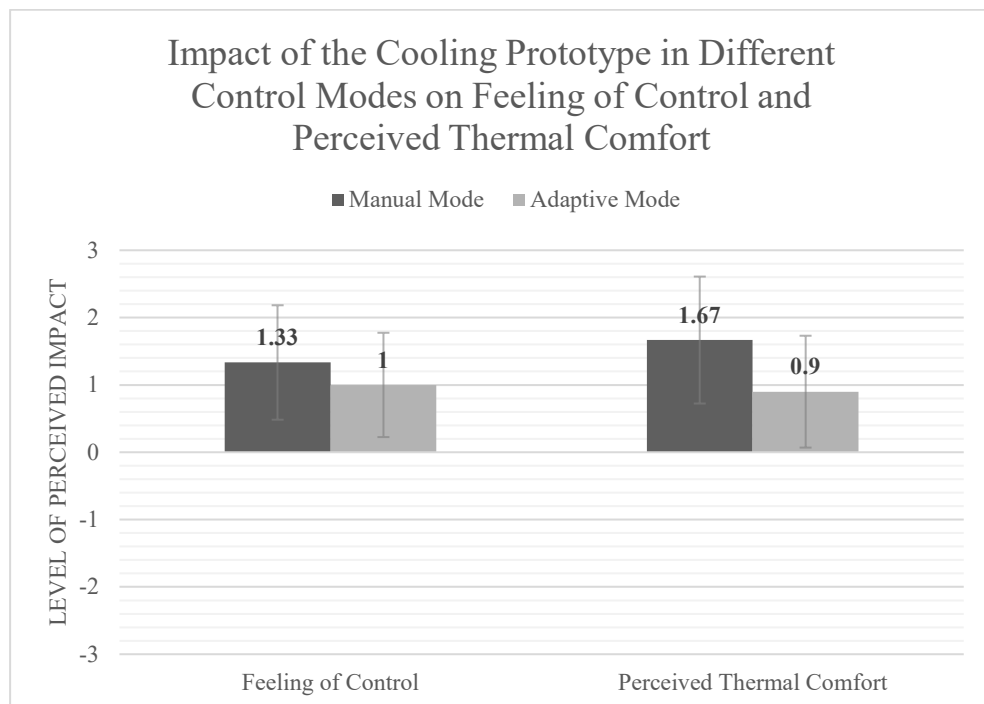


Figure 8.14: Reported impact of prototype use on feeling of control and perceived thermal comfort.

An overview of the satisfaction ratings with different aspects of the cooling prototype split for adaptive and manual mode can be seen in Figure 8.15. However, most of the aspects rated referred to the use and usability of the prototype per se. Relevant aspects for the comparison of

modes constitute the amount of cooling, the temperature control and effectiveness. For each of these three aspects the satisfaction rating was higher for the manual mode than for the adaptive mode. The highest difference in satisfaction ratings for the different modes was reported for the temperature, which was rated at 0.92 points higher for the manual as compared to the adaptive mode. The differences of satisfaction ratings for the modes were less pronounced at 0.25 points for effectiveness and at 0.15 points for the amount of cooling provided. Pronounced differences in satisfaction ratings with other aspects of the cooling prototype between modes were found for the rating of appropriateness in context with a difference of 0.83 points in satisfaction levels and for ease of use in context with a difference of 0.50 points between the manual and the adaptive mode.

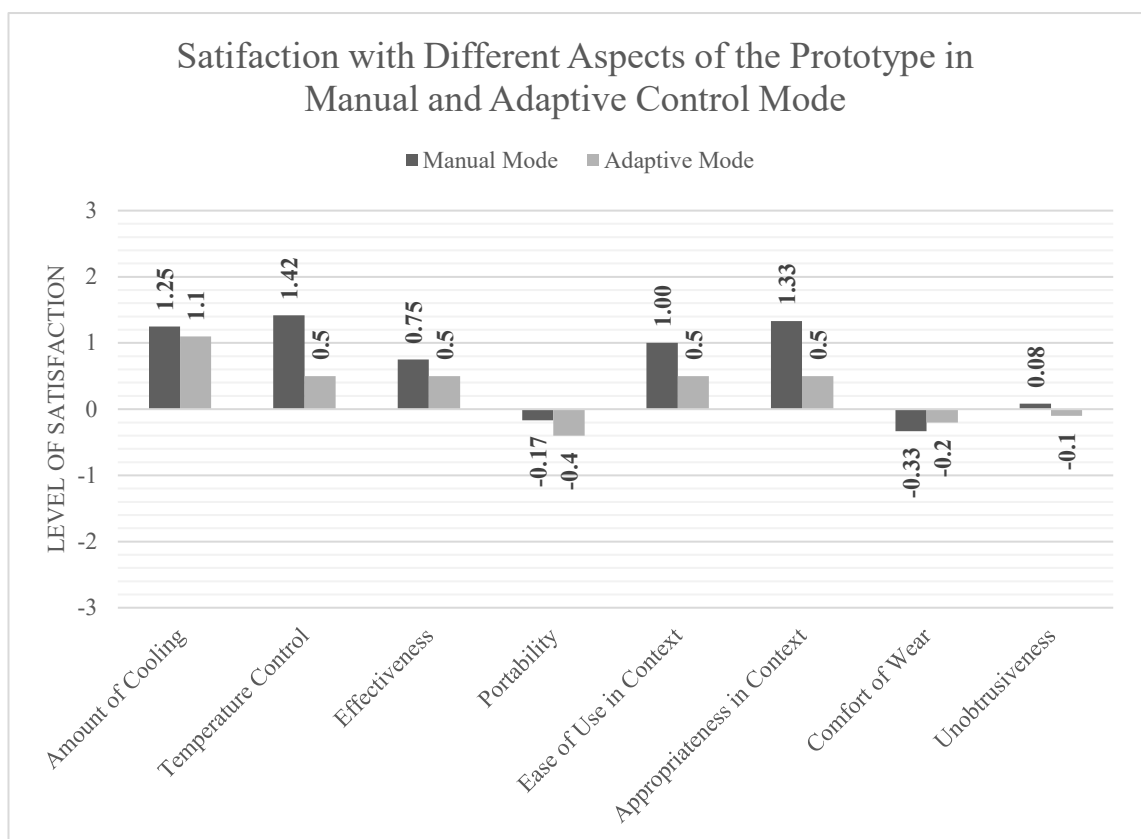


Figure 8.15: Satisfaction with different aspects of the prototype in ambient and manual control modes.

Independent of control modes, participants reported that they were turning the control knob until finding a comfortable setting (P4, P8). However, participant P4 mentioned that in the ambient setting, they felt fiddling with the control messed up the setting. Furthermore, one participant mentioned that they found it difficult to switch between the modes, as the switch was hidden, and therefore they did not try (P5).

Perceived Differences between Control Modes

When asked during the interview, how they would describe the modes and which mode they set the prototype to during the last episode of the user study, four participants (P3, P7, P9, P12) stated that they did not perceive a difference between the settings. Participants attributed this to a lack of change in the ambient temperature, which would affect the adaptive mode, and more pleasant or cooler environmental conditions in general, which meant they were not using the device extensively or put it on a low, less perceptible setting. One participant mentioned that after they set the device to a setting, which they found comfortable, they did not pay attention to it anymore and therefore could not comment on control mode differences (P9). Three participants stated that they found that the device in one of the modes got cooler than in the other (P1, P5, P10) and cooling was more continuous (P5). Participants P1 and P10 indicated that this happened with the device in the ambient control mode, whereas participant P5 could not recall in which one. However, nevertheless P5 stated that the device in the cooler mode also allowed her to feel the cooling in a more continuous way.

Perceived Experiences of Control Modes

The manual mode was perceived as *“that normal control”* (P4). Participant P4 reported feeling more comfortable and less concerned with changing the setting in the manual control mode. He stated:

“It was more I felt ‘oh, it’s okay to change because it’s that normal control’. I don’t need to think I’m working against the system. I’m just turning it when I need to turn it. I don’t need to think.” (P4)

Another participant reported that changes in the temperature were more perceptible and immediate in manual mode (P2). Participant P2 also commented positively on being able to choose the degree of cooling in manual mode as compared to the adaptive, ambient mode. Several participants reported that they did not perceive much of a temperature change of the device in the adaptive mode or that it was not very obvious (P1, P2). Other participants stated that *“ambient felt more natural”* (P6), *“more intuitive”* (P8) and *“easy to use over the manual”* (P6). They experienced the adaptive, ambient control mode also as less aggressive temperature-wise (P8) and reported that it stayed at a *“nice cool temperature”* and therefore felt more comfortable in this mode (P6). In turn, the manual mode was described as *“a bit more brutal”* (P8) and *“almost too cold”* (P6). They also commented positively on not having to readjust or to move the device on body in adaptive mode due to the setting regulating itself as such (P6). One participant found the self-adjusting mode quite convenient:

“just let itself adjust the temperature” (P9)

“it works quite well, so I don’t have to do anything extra” (P9)

However, one participant stated that their struggles with the ambient, adaptive mode as follows:

“I think with the first, with the ambient control, I was almost double guessing it, and then I fiddled with it when I shouldn’t have fiddled with it. Then I was like ‘oh, I don’t know where it is no’ cause I felt like the first time I set it, I think, I set it too cold maybe? Then I know I had to leave it alone and let it regulate itself, but I was still going, ‘oh, it’s too much’ and it was on my arm.” (P4)

In consequence, they felt that they were committed to their choice once having chosen a setting (P4).

Expressions of Preference for Manual versus Adaptive Control

Although this is not supported by the quantitative ratings presented above, six participants expressed a preference for the ambient control mode over the manual one in the interview sessions, either because it adapted the cooling relative to the ambient temperature (P6, P8), adjusted itself autonomously (P12) and therefore was more convenient (P9) or because they felt it got colder (P1, P10). One participant (P4) stated a preference for the manual mode. He reported feeling *“much more in control”* (P4) in the manual mode. Another participant reported preferring different modes at different ambient temperatures. She chose to use the manual setting when feeling really hot to cool down as quick as possible (P2) and to let it adjust the temperature by itself when it was warm (P2). One participant stated not having any preference (P5), as the setting it was set to worked.

8.4 Discussion

Personal control over temperature is one of the key issues in shared and open-plan offices. Over all studies presented, personal control received the one of the lowest satisfaction ratings in the IEQ surveys undertaken. Increasing individual control over the personal thermal environment is consequently one of the main reasons underlying the use of individual devices. This study looked at how a personal wearable thermal cooling device can provide an additional level of control to occupants in context as well as how participants respond to having the device adapt automatically versus having to control it manually, which were both areas identified for further research (Vesely et al. 2017; Udayraj et al. 2018).

8.4.1 Manual vs Adaptive Control: A Matter of Convenience and Acceptance of Foreign Agency

Although studies suggest that giving occupants more control over their thermal environment improves perceived thermal comfort and satisfaction (Heerwagen & Diamond 1992; Leaman & Bordass 2005), exercising or having to exercise control might have the opposite effect (Paciuk 1990). Heerwagen and Diamond (1992) mused that the occupant experience might be negative if too many decisions are required, the process is too complex or control has to be exercised too

often. A higher cognitive load involved in having the additional task of controlling the environment while performing work was also considered the reason for the negative effect on productivity ratings in a study conducted by Boerstra et al. (2015). To study and understand the trade-offs involved and considered by users, this study tested two control settings for a wearable cooling prototype, namely, a manual mode and an adaptive mode, which reacts to changes in ambient temperature.

Feedback from study participants showed that having more control over individual thermal comfort did increase the reported perceived comfort and satisfaction in general. However, it also showed a discrepancy between quantitative and qualitative ratings of the manual in comparison to the adaptive control mode. As was reported in the interview sessions, most participants were happy to let control decisions be taken autonomously by the device to decrease the frequency of having to manually control and change temperature levels and expressed a preference for this setting. However, the satisfaction ratings in respect to control related aspect as well as the perceived impact of the control on thermal comfort and the feeling of control were lower for the cooling prototype in partially automated control mode than in the manual control mode. Research studies on the impact of control settings of PEC systems on productivity and thermal comfort found that the objective and perceived performance of participants was higher when the system was automatically controlled in comparison to manually controlled (Boerstra et al. 2015) and that it did not impact perceived thermal comfort (Vesely et al. 2017), although participants in both cases reported a preference for the manual control setting.

In contrast to previous findings in survey studies (Duval et al. 2010), which found serious safety concerns of users in respect to autonomous control of wearable systems, suggestions for improvement given by participants in this study indicate that better adaptation mechanisms including autonomous response to body temperature and more intelligent control are desired aspects for wearable thermal comfort devices. As other participants preferred to retain control and manually adapt the temperature settings, both modes that were tested have their merits and having the preliminary decision which pathway to take resting with the user allows to address the safety needs of the individual. Also, the adaptive control mode tested still allowed participants to retain partial control of the device by setting an initial strength of cooling. An aspect not tested in the scope of this study regards people's attitude towards full autonomous control by a smart wearable system. However, participants reported anxiety not understanding control settings and the behaviour of the device. Although the acceptance of devices that address physiological needs, such as cooling or heating, are reportedly high, special care needs to be taken in respect to their ease of use as well as the appropriate design of any adaptive, partially autonomous control mode, due to concerns that accidental misuse might cause bodily harm (Duval et al. 2010). In respect to technical devices it has been shown, that

perceived ease-of-use is also one of the key aspects in the adoption of new devices, as it is closely related to confidence of use (Buenaflor & Kim 2012).

8.4.2 Perceived Body Imbalances, On-Body versus Off-Body Control

The device tested in the study could be easily removed from the body if participants did not feel comfortable wearing it and it did cover only a small part of the body. However, attitudes towards adaptive or autonomous control could be different for smart garments, which cover a larger and more sensitive area of the body and cannot be removed so easily. Participants reported serious shortcomings in the design of the device, for example, producing a localised cooling effect, too strong cooling and physiological adaptation, which inhibited prototype use, usability and usefulness. The localised cooling effect proved counterproductive and led to an imbalance in body perception. The recently released wrist-worn cooling device Embr Waves overcomes the adaptation effect by applying temperature in waves at second intervals (Embr Labs 2018). However, it still has to be seen if this also alleviates the perceived body imbalance that was found to affect the satisfaction with the device and impact perceived thermal comfort negatively.

8.5 Summary

The user study presented in this chapter studied the acceptance of a smart wearable cooling device and the trade-offs involved in the decision making between the convenience of smart adaptive control and the autonomy of manual control. The findings were ambiguous, as a discrepancy between the reported preference and ratings of smart ambient control and the recorded ratings of manual control was found. The qualitative feedback of participants supports previous findings in the field that smart adaptive control reduces the mental load of participants, whereas manual control increases perceived control. However, the impact of the control mode on perceived thermal comfort was found to be in favour of manual control.

Chapter 9

Discussion

This chapter reflects on the findings presented in chapters 4 to 8 and discusses the results across the studies in respect to the formulated research questions. This thesis set out to provide an understanding of how occupants achieve thermal comfort through the use of personal thermal devices and adaptive practices and how this use impacts perceived individual comfort, satisfaction and perceived control in the context of open-plan offices. The key findings in respect to the achievement of thermal comfort in this context facilitated by personal thermal devices will be discussed in the first subchapter 9.1, which include the challenge of achieving thermal comfort and how it is addressed by participants through behavioural adaptation, the dimensions inherent in the achievement of thermal comfort observed on individual scale through prototype use and adaptation, and how the availability of personal devices improved the sense of control and perceived thermal comfort.

Furthermore, this thesis addressed the question of how wearable and portable personal devices for thermal comfort have to be designed to support perceived thermal comfort, control and use in context. The key findings in respect to the design of wearable and portable personal devices arising out of the study of thermal comfort will be discussed in subchapter 9.2 and include the design for appropriation, adaptation and emotional needs, the importance of modalities in addressing thermal comfort, and the social role of the artefact at the crossroads between functional element and fashion item.

The chapter concludes with the critical discussion and evaluation of the research approach and methodology and reflects on how the presented study of individual thermal comfort through the use and design of personal devices for thermal comfort in the field and using transdisciplinary mixed methods contributes towards transactional research on individual thermal comfort as well as wearable design and can inform further work in both fields.

9.1 Discussion of Key Findings on Thermal Comfort Across Studies

In this section the key findings in respect to individual thermal comfort through the study of personal thermal devices in context are discussed, which are based on the findings of the user studies presented in chapters 5 to 8 and the pilot survey presented in chapter 4. The key findings highlight recurring topics across the studies, which include insights on the achievement of

thermal comfort in the field, the dimensions of comfort observed in the appropriation of artefacts to support thermal comfort and the implications of control through the availability of personal thermal devices.

9.1.1 The Challenge of Achieving Thermal Comfort in Shared Offices Spaces: Findings from the Field

In the studies presented in chapters 4, 5, 7 and 8 IEQ surveys were undertaken to assess the perceived comfort of participants in their workplace. Across the studies, sound privacy, personal control over the thermal environment, air quality and quality of thermal comfort received the lowest satisfaction ratings. An exception was found in the reported satisfaction levels presented in chapter 5, in which a more detailed questionnaire was employed and the visual contact with indoor plants, the view from the desk and to the outside received low ratings.

The survey results show that achieving individual thermal comfort in shared office environments is and remains a challenge for occupants. Behavioural adaptation was found to be key in achieving comfort across the studies reported in chapters 5, 7 and 8, in which questions on adaptational measures were included in the pre-study questionnaire. Differences in behavioural adjustments could be seen between adjusting to feeling cold and feeling hot, with responses to feeling cold mainly taking place on a personal level, whereas participants predominantly reported undertaking adjustments on the level of the environment when feeling hot. Adding layers of clothing is the most reported action taking place when feeling cold. When feeling hot participants reported most often to open windows or turn on a fan alongside removing a layer of clothing as a third option.

This corresponds to the enacted behavioural adjustments recorded in the low fidelity user study in chapter 6. Given the choice between using a fan and a wearable prototype, participants would most often choose a fan and airflow for cooling whereas wearable on-body measures were preferred for heating cases.

Although adaptive opportunities of the environment were reported to be taken when not feeling comfortable, the qualitative feedback given by participants further elicited that it is very often unclear, how the thermal environment is controlled and by whom. Participants hinted at a feeling of impotence and induced lack of agency when it came to exercising active control over their environment and complained about the behavioural measures taken by colleagues, which would affect their thermal comfort negatively. However, they also admitted a reserve to openly express their discomfort and ask for changes to be made in the environment. Accordingly, one participant stated to rather “suffer in silence”. In turn, concerns for the discomfort of others when operating environmental controls had also been reported by many explaining their choices for or against specific behavioural adaptation mechanisms, as participants, for example, reported to prefer switching on fans for airflow, but only would do so when no-one else was in the office.

These behaviours are in line with research and observations in the field, which suggests that shared offices reduce the perception of ownership, which affects agency and perceived individual control (O'Brien & Gunay 2014) and that occupants act against personal preferences due to concerns of affecting the comfort of others and violating social norms (Borgeson & Brager 2008; O'Brien & Gunay 2014). It has also been found that very often the underlying preferences, needs and etiquettes in respect to the social organisation of thermal comfort remain “unspoken” (Borgeson & Brager 2008, p.6).

Accordingly, communication among occupants in managing their joint thermal environment seemed key to improve psychological satisfaction in the studies conducted. But social dynamics were varying widely across different offices according to the accounts given by participants. In some offices, participants reported to openly discuss and negotiate changes in the states of adaptive opportunities with their co-workers, such as opening/closing windows or switching on/off fans, while in other offices they reported that individual occupants would make these adjustments without consulting others, which stirred up the discontent of their peers and in some cases lead to counter actions taking place.

Although an increasing number of research is looking at how occupants' behavioural adaptation can be modelled or how occupant behaviour affects the energy-efficiency of buildings post occupancy, observational studies in the field remain scarce (O'Brien & Gunay 2014). However, in line with short comings pointed out before by Chappell and Shove (2005), the findings of the studies conducted in the scope of this thesis suggest that further research on how the socio-cultural environment, social dynamics and the bottom-up experience of occupants influence behavioural adaptation as well as perceived comfort in the field is needed.

9.1.2 Achieving Thermal Comfort in Practice: Adaptive Behaviours and Dimensions in the Perception of Comfort

The rich data collected in the scope of the field studies described in chapters 5, 7 and 8 furthermore provided an insight into the achievement of thermal comfort in practice and of the complexity of the adaptation and appropriation processes taking place. Feedback collected in the right-now surveys showed, that in addition to the thermal devices provided, participants would use other forms of behavioural adaptation, such as adding or removing clothing, turning on and adjusting heating or fans, or opening windows or doors. This suggests a cumulative and diverse approach to achieving thermal comfort, which has also been noted in previous research on the use of different adaptive opportunities in offices (Raja et al. 2001). However, it also was stated by participants that the availability and use of a personal thermal device affected and reduced the use of other measures or initiated additional behavioural adjustments. This indicates that personal solutions have to be considered part of a set of available activities and measures supporting the achievement of thermal comfort and do not constitute the sole provider.

A similar complexity was encountered in the contextual interpretation of personal thermal prototypes by participants to suit their thermal comfort needs. It was found that an active exploration process took place, in which participants explored the affordances of the prototypes in respect to the constraints of their physical and task environment as well as habits and thermal comfort needs. This was expressed in the aim to find the right position, which would be both comfortable and convenient. The majority of participants across all field studies reported testing the prototype they were given on different body areas. Most of them also indicated a preferred position or one they used more often than another as the result of the exploration process. However, some participants also reported shifting the prototype between locations depending on the task at hand, for example, from holding the portable prototype while reading to keeping it on the lap when typing in chapter 7, or due to changing thermal discomfort, such as getting cold hands or feet. Behavioural adaptation processes on environmental scale are thus complemented by appropriation processes taking place on a personal, smaller scale, in which occupants try to interpret the control and adaptation mechanisms available to them to suit their needs. Although appropriation and adaptation of personal thermal solutions have not been studied as such before, similar processes have been observed in respect to environmental controls in the analysis of surveys, in which respondents reported on the appropriation and ‘repair’ of building controls (Moezzi & Goins 2011).

The process of exploration extended towards the close personal environment for both wearable and portable devices. Participants were found to place the prototypes in close proximity to their body by augmenting or appropriating objects within their personal space to achieve thermal comfort. Examples include the augmentation of the office chair with a wearable heating or cooling device, as enacted by participants in the studies in chapter 6 and 8, or the adaptation of objects, such as a pile of books to direct the airflow of a personal fan (see chapter 6) or a jacket at the backrest of a chair to hold a hot water bottle (see chapter 5). Suggestions to map and overlay heating or cooling functionality onto everyday objects of personal use, such as desks, mouse mats, chairs, further illustrate the drive to extend the body and the alleviation of bodily needs in form of thermal comfort towards the environment. According to phenomenology, however, the extended body has an inherently different status than the body that incorporates tools and processes, which is distinguished in the description of the ‘body-as-object’ and the ‘body-as-subject’ (Thompson & Stapleton 2009, p.29). The goal of wearable thermal devices is to mediate human thermal experience in the world and allow users to experience the world through them, which can be considered supporting a subjective body relationship. In contrast, thermal devices as features of the environment are in a perceived objective relationship to the body. Body-as-object and the body-as-subject is also the phenomenological distinction, which underlays the concepts of cognitive versus sensory control found in the study described in chapter 6.

9.1.3 Facilitating Perceived Control and Perceived Thermal Comfort with Personal Devices

Increasing perceived personal control over the thermal local environment and in consequence perceived thermal comfort in shared and open-plan offices is one of the main targets of PEC systems (see chapter 2.1.5) and wearable systems for thermal comfort (see chapter 2.2.4). As discussed in subchapter 9.1.1., perceived control over the thermal environment was among the lowest satisfaction ratings across all IEQ surveys undertaken in the scope of the presented studies. The introduction of personal thermal devices in chapter 7 and 8 led to an increase in perceived control over their local thermal environment as well as perceived thermal comfort. The reported impact ratings were highest for the wearable heating prototype and the manually controlled cooling prototype. In the case of the heating prototype, the amount of heating provided by the prototype as well as the physical affordances of the prototype were reported as reasons for participants' preference.

Although various participants across all user studies suggested an active smart device that would adapt to their body temperature and provide automatic control alongside manual control as a desirable improvement, the evaluation of the cooling prototype in chapter 8, which was designed to study the acceptance of an adaptive system and the trade-offs considered in the choice between manual and adaptive control, showed a discrepancy between expressed preference and rated impact. The manual control mode was rated to have a greater positive impact on the perception of control and thermal comfort. However, the majority of participants mentioned during the interview that they had preferred the adaptive control mode, as it relieved them of the task of having to manually control and change temperature levels. The reported preference aligns with previous research, which suggests that having to exercise control too often might have a negative impact on user experience and satisfaction (Heerwagen & Diamond 1992) and has found that the objective and perceived performance of participants was higher when the system was automatically controlled in comparison to manually controlled (Boerstra et al. 2015). The suggestions for smart control of personal devices expressed by several participants and the reported overall preference for adaptive control observed during the user study in chapter 7, however, stands in contrast to previous research findings, which reported serious safety concerns of users in respect to autonomous control of wearable systems (Duval et al. 2010). The affinity and exposure of participants to new technological advances and this type of technology in particular as members of the School of Electronic Engineering and Computer Science might have biased their response, although critical aspects, such as anxiety experienced in not understanding the settings and how the device responded to changes, were also addressed.

The contradiction in participants' rating versus expressed preference suggests that further research into the impact and perception of different control modes of smart wearable

thermal devices in combination with qualitative as well as quantitative thermal comfort assessments is needed.

9.2 Discussion of Design Implications for Wearable and Portable Personal Devices for Thermal Comfort

In this section design implications for the development of personal devices for thermal comfort are discussed based on the findings of the user studies presented in chapters 5 to 8. To support the usefulness, user experience and acceptance of these devices a case is made for openness in the design of affordances of personal thermal devices to support appropriation and adaptation, to respect preferences in thermal modalities and the resulting extension of the perceived body environment, and to address the social role of wearable devices, shifting the focus of wearable design towards wearability and fashion.

9.2.1 Beyond Affordances: Designing Personal Thermal Devices to Support Adaptation, Appropriation and Emotional Needs

Whereas most previous research into PEC systems has looked at either in-built or solutions targeted to specific body parts in the case of wearable options studied to provide thermal comfort (see chapters 2.1.5 and 2.2.4), this work used an open design approach to prototypes and aimed to give agency to the users to study the needs of people and the achievement of thermal comfort in context. As could be observed from the existing devices employed in the study presented in chapter 5, commercially available wearable thermal solutions are also commonly building upon garment related metaphors, such as jackets or gloves, which in turn means that they are tailored for wear on a specific body part. However, it was found across the field studies conducted that participants interpreted the artefacts in respect to their personal needs, depending on constraints, habits, comfort and context, thus creating alternative uses to the intended use of the object, which was recorded in their acts of appropriation and adaptation.

The complexity found in the actual use of an artefact in comparison to its intended use has been highlighted by Redström (2006), who suggested that the interpretation of artefacts becomes necessary when introduced into a real-life context. Also, the appropriation of technology has been frequently observed in field studies with users interpreting the use of systems to suit their specific needs and context of use (Carroll 2004; Sengers & Gaver 2006). In thermal comfort research, however, this aspect to the use of stationary or wearable PEC systems is frequently overlooked, as studies are majorly performed in lab-based environments or artificial set-ups to imitate real-life conditions.

In respect to the design of applications for thermal comfort, it was found in the study of personal heating devices described in chapter 7 that appropriation originated not only from functional needs and the necessity to balance constraints of the context, affordances of the prototypes and thermal comfort but also from emotional needs and the consideration of habits, perceived experience and psychological comfort. In situations, in which thermal discomfort was the predominant factor in participants' experience, the form, location and functionality of the prototype was decisive. In this case, as was also found during the study of existing devices presented in chapter 5, devices were well received if designed for wear on a part of the body that constituted a source of discomfort. For example, this included the heated socks or cooling neck tie presented in chapter 5, as the thermal perception of feet and hands in cool environments and of the head, face and neck in hot environments have a strong impact on the overall perception of thermal comfort (Arens et al. 2006a; Arens et al. 2006b).

However, in situations, in which no acute thermal discomfort was experienced, aspects of use and design supporting the psychological layer of thermal comfort and emotional needs influenced the participants' choice of prototype and preference, for example, for the portable prototype in chapter 7, which helped to release stress and was likened to a pet, or the heated shoulder pad in chapter 5. Overall, the study showed that users consider, balance and appreciate different layers of design, but also that they choose and reason their preference in relationship to their most dominant needs and that those needs can change depending on the circumstances. This was expressed by participant A10 in the study, who explained the difference in the ability of the wearable prototype to provide warmth, i.e. functional comfort, compared to the ability of the portable prototype to make him comfortable, i.e. provide psychological comfort.

For the design of personal thermal devices this implies a shift from the focus on purely functional aspects and the alleviation of discomfort towards the provision of thermal comfort on a holistic level including the psychological, emotional layer or comfort of mind. Although general trends on the functional level persist, as the preference of on-body applications for conductive heating in comparison to off-body applications for convective cooling discussed earlier in this chapter, this work has further shown that beyond the functional level versatility and open design is key to the use and of personal thermal devices by allowing for adaptation and appropriation, which increases the usefulness of devices and contributes to their acceptance due to an added sense of ownership (Dix 2007).

9.2.2 From Function to Fashion and Beyond: Addressing Social Needs in the Design Personal Thermal Wearables

The importance of addressing reflective aspects and catering for emotional needs in the design of personal devices for thermal comfort has already been highlighted in the previous subchapter. Additional aspects to consider in this respect are the aesthetic qualities of the wearable.

Aesthetic and expressive properties of wearable devices gained particular relevance in the user studies, as they were perceived as accessories or garments and the boundary to clothing and fashion was crossed. As mentioned in chapter 2.2.3., aesthetic wearability affects the self-image of users, as the wearable as a fashion item stands in dialog with the social environment (Uotila et al. 2006). Beyond the functional aspect of providing thermal comfort it constitutes a means for self-expression and display of social status, which has been found to play an important role in the acceptance and adoption of technology (Dunne et al. 2014). Respective limitations of the prototypes developed and employed in the studies were consistently pointed out by participants, who desired a more fashionable look and alternatives that would better match and integrate into their clothing style (see chapters 5 and 7) or a more inconspicuous appearance (see chapters 7 and 8). Also, repeatedly reported feelings of awkwardness associated with the wear of the prototypes in the social context and suggestions brought forward (see chapter 7 and 8), which included to allow for customisation of the colour or size of the prototypes or a modular approach of the heating source to go with a flexible, custom carrier layer, can be read in this regard.

Participants showed an awareness of social implications and voiced concerns in regard to the intrusiveness and inconvenience of personal heating and cooling devices also to others. Accordingly, participants expressed a preference for personal devices providing directed thermal output, either in form of a wearable using conductive heating (see chapters 5, 6 and 7) or by allowing to tailor and direct airflow (see chapter 6). This was complemented by the wish for the technology and functionality of wearable devices to remain hidden from view to not draw attention and the use of modes of control and interaction, which integrate into the situational context and are socially acceptable (see chapter 6). In consequence, metaphors suggested by participants to orient the design of personal thermal devices towards primarily constituted of garments, such as cardigans, wearable accessories, such as a scarf, or close at hand objects, such as a mouse mat or seat cover. The desire for constraints to counter obtrusiveness seems to contradict the case made above for the open design of personal devices to support adaptation and appropriation. However, it rather highlights and further stresses the need for the development of thermal devices, which can be configured according to users' needs while being able to address fashion trends and allowing for expression of self (Page 2015).

To highlight this issue in the development of wearables, the newly released Embr Wave constitutes a first step towards fashionable and aesthetically pleasing wearable devices for thermal comfort. The initial evaluation of existing personal thermal devices conducted in the scope of this thesis (see chapter 5) had found a focus on function rather than fashion. If personal devices for thermal comfort are to become a commercial success and be accepted and adopted in corporate contexts, aesthetic qualities and the design for inconspicuous use will have to be addressed.

9.2.3 Reviewing Design Implications to the Design for Usability and User Experience in Personal Devices for Thermal Comfort

The challenges of the design of personal, and in particular wearable, systems have been described as technological, physical, functional and psychological. As was observed across the user studies presented in chapters 5 to 8, the key aspects to address in the functional design of personal devices for thermal comfort can be summarised in the ability to provide heating/cooling when needed (availability), where needed (location), in the amount needed (control), as long as needed (reliability). In addition, the mode of delivery, i.e. whether convective or conductive, on-body or off-body, affects the perceived usefulness of the device and its acceptance.

Additional functional challenges for wearable devices have been defined to be ‘unmonopolizing’, ‘unrestrictive’, ‘observable’, ‘controllable’, ‘attentive’ and ‘communicative’ (Mann 2001), which address essential aspects of usability and user experience design (Rogers et al. 2015). It was found in the user studies that unrestrictiveness in context was supported by openness of form and fit, as this supported adaptation and appropriation by the user to suit their needs. Smart adaptive control in turn was found to support the device’s attentiveness and increase its usability in transient conditions and dynamic environments but also to make it unmonopolizing of the users’ attention allowing them to forget about it (see chapters 6 and 8). Furthermore, it was found in chapter 6 that different control modalities, i.e. on-device and remote control via a smartphone application, as well as their implementation, which could support both cognitive and sensory control as well as observation of the device and its state, could cater for different user preferences, but also address psychological challenges resulting out of the interaction with the device implications in specific social contexts and situations.

Additional aspects to address in the design of personal thermal devices related to physical and form-related challenges of wearability. Openness in design (see chapter 7), as opposed to design for a specific fit and body location, supports variability of body form and allows for appropriation in context to address the needs of the individual. It was found furthermore that needs and requirements of users in respect to thermal comfort transcend different layers dependent on the most pressing need prevalent at a certain point in time, an aspect, which is not addressed in current discussions of wearable design or thermal comfort. However, the differences between functional and psychological need were observed to let different design characteristics and affordances of devices come to the foreground, such as size of heated area versus the materiality and feel of the device, as well as elicit different experiences of thermal comfort, expressed as feeling warm versus feeling comfortable (see chapter 7). Wearability challenges related to size, weight, balance, and washability could only be addressed to a limited degree in the scope of the design of the prototypes, due to the limits of their fidelity. However, these factors, alongside technical challenges, such as battery life and power supply

and the size of components, were mentioned in the feedback of participants to have affected the usability of the prototypes and can thus be considered critical in the implementation of any potential wearable thermal device.

Finally, psychological aspects including self-image, social acceptance, and inconspicuousness of use in the design of personal wearable devices for thermal comfort were found to require taking particular care of aesthetic qualities, such as pattern, colour and materiality and design of line, as these devices naturally transcend the boundary between function and fashion.

9.3 Discussion of Methodological Approach

In the scope of this thesis a RtD approach was implemented to address and reframe questions on individual thermal comfort, how it is achieved and perceived, and to study the implications on the design of devices to support it. Mixed methods from two domains, namely, thermal comfort research and human computer interaction, were employed to study and contribute to an understanding of individual thermal comfort through the design and use of personal devices and to inform the design of future wearable devices through the lens of human thermal comfort. The challenge was not only to capture the changing and dynamic nature of perceived comfort of the participants in their environment but also to capture the interaction between the user and devices in the field. In the following subsections the methodological approach will be critically discussed, and short comings and limitations of the approach and methods will be pointed out.

9.3.1 Research Through Design: Thermal Comfort Through the Looking Glass

Design is transformative and affects the world and interactions taking place within it (Crouch & Pearce 2012). A RtD approach was implemented with the aim to reframe the respective problem spaces in both human-centred thermal comfort research and research into the design of personal systems for thermal comfort towards desirable and alternative states of reality through the design of artefacts (see chapter 3). Accordingly, the studies presented in chapters 5 to 8 were centred on the implementation of design artefacts as investigative objects and vehicles for inquiry, the evaluation of which in situ, in form of an exploration of the relational presence and use of the object in the lived experience of the participant, addressed the question of thermal comfort from the bottom up (Welton 2005).

The approach allowed to study real-life actions and experiences more holistically as a transactional relationship between objects, people, and environment and in an exploratory way, which allowed themes, such as the exploration involved in the achievement of thermal comfort

or the need of open-ended design in personal devices to support adaptation and appropriation to evolve and surface. It therefore contributed to a better understanding of the ways occupants experience and achieve thermal comfort and the complexity of adaptive measures and strategies they undertake to find the best personal fit with the given resources in the context of use with its constraints. It also allowed to study the interpretation of use of the design objects by the users and the meaning making taking place, which was exhibited in the many ways appropriation and adaptation contributed to the active achievement of thermal comfort and comfort in the general sense.

It was argued in chapter 3 that a combined enquiry of problems that span across research domains can add relevance to the RtD approach, which has been criticised in many cases to miss out on critical aspects and real world impact (Zimmerman et al. 2007). The transdisciplinary approach to the RtD enquiry provided a richer and more holistic picture of the problem spaces under investigation as well as of possible solutions and their implications not only within discipline but also across the domains.

In centring the investigation on the user and applying user-centred design to personal wearable thermal devices, the approach furthermore allowed to understand the needs of users as occupants and members of a specific socio-cultural environment. The extensive analysis phase, which included a survey and two initial user studies employing existing devices (see chapters 4 and 5), was introduced to provide a thorough framing of the problem statement of the investigation, both in respect to the achievement of thermal comfort as well as the design of personal devices. The extensive analysis also provided the base for the development of relevant and suitable design prototypes for the investigations presented in chapters 7 and 8, which was further grounded through the testing of initial design ideas in a low-fidelity user study (see chapter 6).

Limitations of the Approach

Although the perceived flexibility and the design for adaptability allowed the design artefact to act as catalyst for participants to answer questions about their achievement of individual thermal comfort through their use of the artefact, this meant that the limitations of the approach were closely tied to the limitations of the artefacts themselves as well as the selection of participants and the context of use (Redström 2006; Kelly & Matthews 2014). The design of a prototype has been described as an interpretative act, which carries the risk of manifesting an answer to the question under investigation but also of involuntarily embodying pre-existing biases in the design (Galey & Ruecker 2010; Friedman 1996). Flexibility in design allowed the reinterpretation of the artefact by the participants and thus to uncover conscious as well as unconscious biases inherent in the design to some extent. For example, the prototypes were designed for personal on-body cooling and heating as opposed to off-body personal thermal devices in the local environment, such as mouse pads, chair covers, or on desk fans, which are

what participants requested or appropriated the prototypes for in both field studies that were conducted (see chapters 7 and 8). This is an indicator in respect to prevailing issues with the prototype design and its functional fit. In the scope of the studies, participants expressed further functional preferences and needs, such as feet as areas of cold discomfort and the preference for off-body cooling and air flow, which were not taken up in the design of the prototypes in favour of more open-ended research questions and investigations.

Furthermore, an unconscious and unintentional bias was found to exist in the design of the wearable prototype for heating, which metaphorically speaking constituted a shawl, scarf or blanket. Due to existing gender stereotypes in apparels, the use of the prototype as a shawl or scarf was limited to female participants. Male participants used the prototype either as a blanket over the legs, a cover for the chair or a heating element on the desk. Only one male participant referred to his use of the wearable heating prototype as a cape. Although it has been stated that biases in qualitative research cannot be wholly avoided (Kvale 1994), neglecting social norms in apparels in this particular case inherently reduced the behavioural opportunities and actual affordances of the device for male participants. Greater care needs to be taken in future research into personal thermal devices by checking for gender related biases inherent in the design of the wearable artefacts and reflecting on the assumptions underlying design decisions (Kvale 1994).

Limitations of the prototypes in practical terms, i.e. the limitations of available technology, the power supply and the implications on the size of the prototype and its wearability and usability, biased the use of the prototypes and was shown to some extent inhibit participants' actions. For example, participants reported preferring not to use the wearable and portable on the back because they did not find a place for the battery in this position or were afraid of damaging the sensing circuit when leaning back. The question of technological aspects, power supply and with it matters of duration of use and efficiency, size and wearability have been noted as challenges in wearable design early on and still hold true (Starner 1996; Starner 2014). In particular power consumption has been noted as an important issue still to address, as it affects acceptance and portability of devices (Hanuska et al. 2017). Although the cabling and the battery were major drawbacks of the prototypes, the idea of having portable/wearable devices to support thermal comfort were received positively by participants. Participants tried nevertheless to make the prototypes best suit their needs and adapted to the short comings of the prototypes, finding work arounds in respect to cabling, battery, sensors.

Also, the technologies of the devices chosen and built had an impact on the ratings and expressed preferences of the participants. In partial accordance with this, for example, participants stated that they would prefer other ways of cooling than ice packs in chapter 5 or localised cooling provided by the wearable prototype in chapter 8. Although projecting a future state, the prototypes were implemented using technology that was available and accessible at the point of the investigation. However, materials and technologies that will enable future personal

devices for heating and cooling and address some of the technical shortcomings encountered here are already under development (Roh & Kim 2015; Bai et al. 2018).

In addition, it was noticed that participants also referred to or reflected on their use of other known devices during the study. Past experiences and exposures might therefore be the reason why preferred devices were not necessarily also referenced as the most usable and convenient devices for use in context in the study of existing devices in chapter 5. However, the approach did not explicitly address to what extent past experiences, past exposures, and expectations influenced the feedback and the expressed preferences of the participants. Fans, for example, are commonly available and accepted in offices on campus, which could explain why a personal cooling fan has been nominated most often as the preferred device for cooling. In contrast, participant A1 in the study of affordances reported feeling annoyed with the private heating pad she had been using in the office before testing the wearable and portable prototypes described in chapter 7.

9.3.2 Field Studies and Talk out Loud Scenarios Revisited: Evaluating the Impact of the Context of Use and Considering Pros and Cons

Field studies have been described as the primary research tool if subjective assessment and experience as well as behavioural aspects in respect to the interaction with devices in the context of use or thermal comfort as a subjective phenomenon and the holistic response and experience of occupants to their real-life environment are studied (Rogers et al. 2007; de Dear et al. 2013). It has been claimed that the actual use of an artefact and the interpretation of its use by the user can only be studied through the introduction of the artefacts into a real-life context (Redström 2008). Studying the use of the artefacts in the wild in the scope of this thesis allowed to uncover the complexities found in the situated use of personal devices for thermal comfort and the adaptation, interpretation and meaning making processes taking place, as described by Redström (2006; 2008).

The differences between a lab-based user study and user study in the field in the context of this work becomes apparent when comparing the results of the low-fidelity scenario-based user study conducted in a controlled setting (see chapter 6) and the mid-fidelity user studies conducted in the field (see chapter 7 and 8). Not taking into account the differences in fidelity and therefore in actual functionality between the prototypes, the lab-based study allowed to study general preferences in the use of personal thermal devices in respect to the choice of modality, i.e. wearable, conductive or portable, convective, and its placement on body and off body. Although participants took aspects of their workplace layout into account while enacting the scenario and also mused about possible placements of, for example, the fan in respect to their body in a real-life setting, this was far from the active exploration, adaptation and appropriation strategies that were reported by participants during the field studies. Whereas the

lab-based study used scenarios as the basis for the enactment of an imagined reality, the field studies allowed to study the complexity of the concepts under investigation based on the actual experience of the prototype in context. The experience of use was further heightened by the actual functionality of the mid-fidelity prototypes and the longer period of time scheduled for their use.

Limitations of the Approach

However, the decision to conduct studies in the wild came with several challenges and disadvantages. Field studies have been criticised to be costly and time-consuming and for providing not enough additional value in return for the effort undertaken (Kjeldskov et al. 2004). Although, the evaluation of prototypes in the field provided the desired insights, the studies were very time intensive taking four to nine weeks each to complete with a limited number of participants and number of completed rounds of testing for each device. The days, on which testing of devices took place, were rarely all consecutive for individual participants, as these were not in the office every day, either because they chose to work in other places or had obligations outside university, such as attending conferences. Furthermore, the maintenance of the study set-up over the course of the study consumed time, as it included changing batteries and checking in with participants regularly to exchange and check devices and questionnaires. Due to the focus of the enquiry on thermal comfort, running studies in the field introduced additional time constraints. Studies could only be run during the respective seasons: in winter to study personal heating and in summer to study personal cooling, which in turn affected design and development cycles and added time pressure to the deployment of prototypes. As the implementation and building of the prototypes took several weeks at a time, their testing was pushed towards the end of the respective season they were built for or a transition period, i.e. March/April for personal heating (chapter 7) and August to October for personal cooling (chapter 8). This affected the usefulness of the devices in context and their use, as the conditions in these transition periods could be the opposite of what was desired.

The running of the user studies in the field incorporated further challenges. Evaluation had to be integrated into a regular working day, as this was a central point of the study. However, the restriction of data gathering to office hours meant that the thermal and climatic story of participants could not be covered in its entirety and a complete account considered (Wyon & Wargocki 2006). Further disadvantages of field studies include the limited control over environmental conditions and the lack of precision of many field measurements techniques as well as of validity due to a lack of common standards (Oulasvirta 2012). The field settings in the presented studies could not be controlled, which meant that a lot of freedom was given to and agency expected of participants in following instructions and filling out forms in an unsupervised way. Accordingly, the load to the participant had to be limited, which meant keeping the questionnaires to be filled out daily simple and adapting the schedule of reporting to

individual work patterns. Different working patterns but also different interpretations of the set-up led to different amounts of data collected per participant. Also, participants would frequently forget to switch on or off the sensing circuit that tracked activity patterns, to change or charge batteries, and to fill in the forms. In addition, the sensor network proved not always reliable experiencing data drops, interrupted connectivity between nodes and base station or disconnection of specific sensors and therefore lack of readings. Variations in the amount of data had to be accepted in the trade-off between interferences and interruptions to the work day and maintaining a real-life context as closely as possible, as exercising more control and regular checks in respect to data collection might have biased and impacted behaviour further and added more stress.

Last but not least, common problems of field studies were encountered also in this work, which include the low number of participants and a sampling bias, especially if convenience sampling is used, as in this case, participants volunteered and were consequently self-selected (Wyon & Wargocki 2006). It could therefore be argued that those, who participated, did so because the topic of thermal comfort addressed specific personal needs and resonated with problems encountered in their specific work environment, which means the findings cannot be considered representative and generalisable. The low number of participants that was recruited for the studies in the field due to constraints in respect of equipment, man power, time and availability, further contributed to this limitation. However, it has been argued that the question of how many participants are needed does not necessarily apply in qualitative research, as qualitative research aims rather at finding out fundamental aspects in respect to the question under investigation and the underlying meaning than statistical numbers (Kvale 1994; Englander 2012). Furthermore, the observed adaptation strategies have been reported widely in other research and the number of issues and challenges to thermal comfort that could be detected in different office spaces suggest that these are widespread phenomena. This means that, although not all possible view points and strategies in respect to the achievement of thermal comfort could be detected and uncovered due to the limitations of the approach, the number of aspects that were recorded, and the insights that could be generated suggest that perceived thermal comfort from a bottom up perspective has not been addressed sufficiently yet in research and practice and therefore constitutes an area for further research from the perspective of environmental psychology.

9.3.3 Transdisciplinary Mixed Methods: Triangulation of Prototype Use and Thermal Comfort Perception

RtD has been criticised as lacking metrics and guidelines to ensure the validity and reproducibility of the research (Zimmerman et al. 2010; Gaver 2012). To address these concerns, a mixed methods approach employing methods both from thermal comfort research

and HCI (see chapter 3.3) was implemented. Mixed methods help to increase the understanding of the aspect under investigation and to even out individual shortcomings of the tools and methods through triangulation, which reduces the error and therefore increases the validity of the research (Berg 2007).

The mix of methods used in this research included IEQ, right-now and prototype evaluation questionnaires as well as interviews, alongside the recording of environmental data as well as the logging of device activities. The collection of qualitative and subjective data using questionnaires and interviews allowed to capture the perceived thermal comfort of the occupants as well as feedback on their use and experience of the prototypes. The simultaneous collection of quantitative data logging environmental and activity data allowed to relate what was perceived and reported subjectively to objective measurements and to thus provide a deeper understanding of the events and actions. For example, sensor and activity logs provided additional insights into the use of design prototypes, such as duration of use, and allowed to relate usage to general environmental conditions or to particular adaptive actions, such as the opening of windows, which was reflected in the change of temperature and humidity rates. Using triangulation, this provided a more holistic picture of the aspects affecting the need for additional heating and cooling, as the qualitative feedback given on the use of personal devices could be set in relation to perceived thermal comfort and environmental conditions. The transdisciplinary nature of the methods employed increased the level of complexity in the number of aspects and the different levels these could be studied. For example, the richness of the collected data also allowed to set the perceived usefulness of devices in relation to reported device use, which provided an additional level of explanation to the differences in recorded device use.

Limitations of the Employed Methods

Triangulation of the different data sets collected also allowed to uncover discrepancies or contradictions between recorded and reported prototype use or evaluations. Thus, the mixed methods approach allows to pin-point some of the limitations and shortcomings encountered in individual methods. Although, both quantitative and qualitative data collection methods were employed, the studies conducted in the scope of this thesis, which were user-centred in nature, relied heavily on the qualitative insights provided by participants. Qualitative approaches, however, have been criticised for their subjective nature and the subjectivity bias involved in the analysis of the data (Adams & Cox 2008). For example, surveys as tools have been critically discussed in thermal comfort research, as the perception of the occupants and therefore their responses are influenced by the transient nature of comfort and indoor environmental conditions and are based on a large number of factors that cannot all be considered (Peretti & Schiavon 2011). The suggestion from the field of POE to combine questionnaires with interviews, although not taken up in the collection of data on thermal comfort, was implemented in respect

to the evaluation of the design prototypes. The interviews helped to clarify some open questions but also led participants to discover new aspects, reflect on their previous statements and in some cases to revise or moderate these. Subjective feedback has been found to be a conscious reflection on mental, thermal, and bodily states and adaptive actions, which required a high level of reflective awareness on part of the participant, which was challenging.

Another challenge was to overcome the connotation of the experiment and the positivity bias. Agreeing to participate automatically implied a subconscious expectancy of use when prototypes were given to test. Although it was explicitly stated that devices should only be used if needed and when participants felt like using them as well as having stated that non-use was acceptable, participants offered apologies and explanations of why they did not use the devices. Although the tendency to overreport use could in most cases be counterbalanced by comparison with the recorded use, it was still very difficult to assess if the feedback given by participants was too positive or biased in another way. In general, participants were asked and did report negative aspects they encountered in their use of the prototypes.

Asking about participants' preferences and what kind of a device they would wish for or asking for suggestions for improvement were furthermore questions intended to overcome the positivity bias to see whether the devices were indeed perceived as useful in context or if specific issues remained unreported. For example, aspects uncovered this way regarded participants' psychological needs and related to the artefacts' appearance and aesthetic qualities as a substitute for the expression of self and considerations of self-image in the social context. However, it was observed that participants accepted the underlying assumptions inherent in the design and affordances of the prototypes without questioning them. Exceptions to this statement include participants reporting cold feet as the actual problem preventing them to feel comfortable or reporting to prefer off-body cooling and air flow after having tested an on-body, conductive cooling prototype and thus pointing out the inherent biases in the design of the prototypes.

Finally, technical limitations and short comings in the set-up were also experienced in the collection of sensor data and activity information. Data drops occurred in the gathering of the data, as signals from the nodes were sometimes not picked up by the base station due to lacking a line of sight. Furthermore, sensors, e.g. the humidity sensor, sometimes got disconnected within the circuit, as they were plugged in instead of soldered onto the circuit board to enable reuse, which meant that respective data would not be collected. Also, limited battery life and the dependency on participants to remember to plug in the battery at the beginning of the day and to change the battery led to a loss of data. Furthermore, short comings in the collection of device activity information were primarily experienced due to the set-up and the placement of a sensing circuit, which was external to the device activity itself. This set-up required participants to remember to switch on and off the sensing circuit before and after use, which they frequently forgot. The design and implementation of the cooling circuit described in

chapter 8 tried to overcome this issue by integrating the sensing and data transmission into the Peltier circuit.

9.4 Summary

This chapter discussed the results and findings from the user studies presented in chapters 4 to 8. The key findings in respect to the achievement of thermal comfort through the use of personal thermal devices include insights into the active exploration, adaptation and appropriation processes taking place in the achievement of thermal comfort in practice. It was found that behavioural adaptation processes transcend scales, as adaptation of adaptive opportunities on an environmental level is complemented by the appropriation of available devices on the personal scale and that different individual measures are combined to further improve perceived thermal comfort. As one in a combination of measures, personal thermal devices were found to increase perceived control over the local thermal environment and perceived thermal comfort. Through the study of affordances in personal thermal devices (chapter 7) it was found that the affordances of adaptive opportunities on personal scale are actively explored to find the best possible fit between supported appropriation, individual needs, context, and habits. The appropriation and adaptation of artefacts proved to have another level of complexity, as it aimed at achieving thermal comfort across different layers of need, which means that their design has to go beyond the mere functional provision of heating or cooling towards emotional design.

The key findings in respect to the design of wearable and portable personal devices include a recommendation for openness in the design of affordances of personal thermal devices to support appropriation and adaptation and to improve the perceived usefulness, user experience and acceptance of such devices, to respect people's preferences for specific thermal modalities, and to address the social role of wearable devices, shifting the focus of wearable design towards wearability and fashion.

A transdisciplinary RtD approach using mixed method allowed to study the use of prototypes from different angles and to relate it to the topic of thermal comfort. It thus helped to provide a more holistic and varied picture of the complexity of behavioural adaptation processes taking place. Studying thermal comfort and the use of personal thermal devices in a real-world context uncovered difficulties and challenges related to the use of devices derived from the context of use, which would not have occurred in lab-based studies with shorter test periods.

Chapter 10

Conclusion

This chapter summarises the key findings and contributions of this thesis. Furthermore, it proposes further work in the area to address the limitations and shortcomings of the work presented, and additional areas for investigation, which surfaced in the scope of the conducted studies but were out of the scope of this thesis.

10.1 Overview of Key Findings

Although the achievement and provision of thermal comfort is at the centre of many human everyday decisions and actions, a perfect state is often very difficult to achieve in practice. Especially in shared spaces such as open-plan offices, the level of control available to the individual over the local thermal environment is limited and often further constrained by building control and social norms (de Dear et al. 1997; Chappells & Shove 2005). At the same time differences in thermal perception between individuals can vary considerably (Wang et al. 2018), which means that dissatisfaction with the thermal environment among occupants is widespread in open-plan offices today (Cox 2010). As an awareness for the benefits of personal thermal control for indoor environmental satisfaction, health, and productivity has been increasing, so has research into the question of how this could be achieved and addressed (De Dear & Brager 2002; de Dear et al. 2013). In thermal comfort research, PEC systems and, more recently, wearable systems have been investigated as potential solutions to the problem, which can help to address individual differences and comfort needs in the built environment (Mann 1996; ASHRAE 2013).

The majority of available studies in the area, however, were conducted in the laboratory and mainly focussed on the effect of wearable thermal devices on skin or body temperature, thermal sensation, and thermal comfort or energy saving aspects under artificial conditions. Accordingly, studying the effects of thermal wearables on the users and the usability of the devices in their actual context of use (Song et al. 2015), as well as the impact of the socio-cultural context and user appropriation on the use of these devices (Udayraj et al. 2018) had been defined as gaps and areas for further investigation. In response to the challenge, this thesis set out to critically study individual thermal comfort through the use of personal thermal devices in the field and to evaluate the impact on the design of such devices using a user- and design-

centred perspective and adding methods from HCI research to the enquiry to transcend the predominantly engineering centric agenda.

The aims of this thesis were three-fold: to provide an understanding of how occupants achieve thermal comfort through the use of personal thermal devices and adaptive practices and how this use impacts perceived individual comfort and perceived control in the context of open-plan offices as well as how wearable and portable personal devices for thermal comfort have to be designed to support perceived thermal comfort, control and use in context.

10.1.1 Key Findings on the Achievement of Thermal Comfort Through the Use of Design Artefacts

Across the studies, sound privacy, personal control over the thermal environment, air quality and quality of thermal comfort received the lowest satisfaction ratings. Behavioural adaptation was found to be key in achieving comfort across the studies reported in chapters 5, 7 and 8, in which questions on adaptational measures were included in the pre-study questionnaire. Differences in behavioural adjustments could be seen between adjusting to feeling cold and feeling hot, with responses to feeling cold mainly taking place on a personal level, such as adding layers of clothing, whereas participants predominantly reported adjustments on the level of the environment when feeling hot, such as opening windows or turning on a fan. Given the choice between convective and conductive solutions for thermal comfort, participants expressed a preference for off-body cooling based on a fan and airflow, whereas wearable on-body measures were preferred for heating. Feedback provided by participants in the right-now questionnaires uncovered that people employed a combination of methods to achieve thermal comfort in practice and would, for example, add clothing or open the windows and switch on a fan alongside their use of a personal device.

However, the social environment was found to be inhibiting behavioural adaptation but also to be a contributor of sources of discomfort. In consequence, social dynamics in shared spaces have found to play an important role in achieving individual thermal comfort through negotiation, which, however, is an under researched area. Participants reported that how the thermal environment is controlled and by whom is very often unclear and therefore they expressed a feeling of impotence and induced lack of agency in respect to actively taking control over their environment. Participants reported the behavioural measures taken by colleagues, such as the extensive use of fans, to negatively affect their thermal comfort. In turn, considerations for the discomfort of their colleagues affected their choice of adaptive measures and personal thermal devices were found to address this need provided they are designed for inconspicuousness of use and address psychological needs, such as aesthetics and fashion.

Through the use of a personal thermal device the complexity of the achievement of comfort was uncovered. It was found that an active exploration process took place, in which

participants explored the affordances of the prototypes in relationship to constraints of their physical and task environment, habits and thermal comfort needs. This was expressed in the aim to find the right position, which would be both comfortable and convenient. The process of exploration extended towards the close personal environment, as participants were found to place both wearable and portable prototypes in close proximity to their body by augmenting or appropriating objects within their personal space.

Furthermore, the achievement of thermal comfort has been found to be a dynamic process with participants rearranging personal devices on and off their body to match changing comfort needs. It was found in the studies presented in chapter 7 and 8 that the introduction of a personal thermal device increased perceived control over the local thermal environment as well as perceived thermal comfort. In the study that looked at the acceptance of manual and adaptive control modes (chapter 7) it was found that the mode of device control affected ratings of perceived thermal comfort and the feeling of control. The manual control mode was rated to have a greater positive impact on the perception of control and thermal comfort independent than the adaptive setting. However, these findings from impact ratings contradicted reported preferences and perceptions.

10.1.2 Key Findings for the Design of Personal Devices for Thermal Comfort

The key findings in respect to the functional design of personal devices for thermal comfort were found to be the ability to provide heating/cooling when needed (availability), where needed (location), in the amount needed (control), and as long as needed (reliability). In addition, the mode of delivery, i.e. whether convective or conductive, on-body or off-body, was found to affect the perceived usefulness of the device and its acceptance. The introduction of smart adaptive control was found to be a factor, which could improve usability in transient conditions and dynamic environments (chapter 6). In the scope of the user study of chapter 8 it was found that it allowed matters of control to recede into the background of the users' attention. However, a discrepancy between the reported preference and ratings of smart ambient control and the recorded quantitative ratings of manual control was found. Whereas participants reported a preference for adaptive control, their ratings favoured the manual control mode (see chapter 8).

Furthermore, it was found that participants reinterpreted the artefacts during use depending on the context and its constraints, individual habits, and comfort needs, thus creating alternative uses to the intended use of the object through appropriation and adaptation. It was found further that adaptation and appropriation in context was supported by openness of form, affordances and fit. The study on personal heating devices uncovered that the needs of participants transcended between layers, between the functional need of providing heating or

cooling to the emotional need of providing comfort as a state of mind, depending on the most pressing need. This further affected preferences for prototypes based on their specific inherent design characteristics, most importantly regarding form, size, materiality, and body location, as well as their affordances.

Personal wearable thermal devices were found to cross the boundary to clothing and fashion, as participants reported feelings of awkwardness wearing the prototypes in the social context of their office environment and expressed a wish for aesthetic, expressive and custom qualities. Design for inconspicuous appearance and interaction with personal wearable thermal devices as well as focussed thermal comfort provision was further found to be key to the integration into the situational context and are socially acceptability.

In short, it was found that personal thermal devices need to be designed in such a way that they can be configured and adapted according to users' needs for thermal comfort while addressing needs on the social level in respect to fashion and expression of self to eventually support the acceptance and adoption of the technology.

10.2 Summary of Contributions

This work contributes to the body of research in three ways: it contributes new insights and directions for enquiry to the investigation of PEC systems and behavioural adaption in thermal comfort research, design guidelines and insights to the design of personal wearable or portable thermal systems in HCI, as well as a transdisciplinary approach to the expanding body of work in RtD studies. The contributions can be detailed as follows:

- Empirical research looking at the adaption processes taking place in the achievement of thermal comfort in the field showed that behavioural adaptation constitutes a process of active exploration of the affordances of adaptive opportunities, as well as the reinterpretation, adaptation, and appropriation of these in context, and taking into account individual habits. The achievement of thermal comfort furthermore dynamically transcends different layers of physical, functional, psychological and social comfort with the most pressing need coming to the fore and influencing the choice of behavioural adaptive strategies and means (chapter 7).
- Design guidelines for the future design and development of personal wearable or portable thermal systems were derived from the empirical evaluation of design prototypes, which found that the usefulness of personal devices for thermal comfort is affected by their ability to provide heating or cooling when needed (availability), where needed (location), in the amount needed (control), and as long as needed (reliability) (chapter 5) and that an open design of personal thermal devices and their affordances

supports adaptation and appropriation processes in the achievement of thermal comfort (chapter 7).

- The documented approach contributes to the expanding body of work in RtD and can provide a template for future RtD studies, as it was demonstrated in this thesis that a transdisciplinary approach adds the often lacking real-world impact and relevance to the RtD enquiry with transdisciplinary mixed methods increasing its validity. In the particular case the grounding in thermal comfort contributed critical aspects and real-world impact to the design-based enquiry, which was supported by mixed methods stemming from both thermal comfort research and HCI (chapter 9.3.1).

10.3 Limitations and Future Work

Limitations were experienced in respect to the approach, the technical limitations and inherent biases in the design of the prototypes as well as the short comings of the methods and the tools for data collection.

Conducting field studies proved to be costly, as only a limited number of participants could be recruited, time-constraint, as studies could only be run during the seasons for heating and cooling, and time-consuming, as the study set-up had to be maintained and participants had flexible working patterns, so that studies spanned over several weeks at a time. Furthermore, due to the length of the prescribed testing periods over several days, a considerable agency was given to participants to provide feedback and maintain the set-up as intended. In consequence, data was lost because participants forgot to fill in the questionnaire or to activate device logging but also because the implemented network for sensor data collection experienced problems. In respect to the methods used, a positivity bias in the evaluation of prototypes and reports on perceived thermal comfort could not be excluded, although the triangulation of collected data helped to find inconsistencies and pin-point respective issues. In future field studies the reliability of the sensor data collection could be improved by implementing a more reliable sensor network or using commercial IOT solutions and by integrating the sensing and data transmission circuit into the overall prototype circuit. Regarding the collection of subjective data, digital forms could be emailed to participants at specific times or a mobile phone application could be developed, which sends notifications and allows to provide feedback.

Technical limitations of the prototypes and their fidelity were found to inhibit participants' actions and natural use of the prototypes in context and was further found to initiate separate adaptation and appropriation processes. Biases in the design of the prototypes included in-built assumptions on the use and application of a wearable or portable device and unconscious gender profiling, which further biased use. All prototypes were built on the assumption that on-body solutions for thermal comfort would be acceptable to and considered

useful by participants, which, however, only held true in the heating case. The metaphors underlying the design of the wearable heating prototype were based on predominantly female accessories, such as shawls and scarfs. Participants' actions, uses and feedback have to be regarded in the light of the shortcomings of the design artefacts these addressed. Future research into the design of personal wearable and portable solutions for thermal comfort using a design-based RtD approach should more carefully consider the inherent biases in the design of artefacts and address these as part of the on-going investigation.

Apart from addressing the limitations mentioned above, future work can address the following additional aspects that were discovered during the evaluation of the user studies but were out of scope to address in detail:

- Further research into how the socio-cultural environment, social dynamics and the bottom-up experience of occupants influence active behavioural adaptation as well as perceived comfort in shared office environments.
- A closer investigation into preferences of heating and cooling modalities, such as on-body, conductive heating and off-body, convective cooling, the relevant factors involved and potential implications on the perceived usefulness and acceptance of personal thermal devices.
- An investigation into the process of augmentation and body extension, in which the provision of thermal comfort is extended towards the close personal environment in the appropriation of personal thermal devices, the underlying meaning-making and perception of the body, object, environment relationship in respect to thermal comfort.
- Further investigation into smart thermal systems, control paradigms and modalities for wearable systems, which include different levels of smart control, their perception, acceptance and impact on perceived thermal comfort and productivity, as well as the impact of cognitive versus sensory control paradigms on the design of control interfaces, the perception of wearable devices, perceived thermal comfort and the body-environment relationship.
- Investigations into the design of wearable thermal devices for fashion, self-image and social acceptance, the challenges, opportunities and limitations involved.
- Personal wearable thermal devices were found to cross the boundary between clothing and fashion, as participants reported feelings of awkwardness wearing the prototypes in the social context of their office environment and expressed a wish for aesthetic, expressive and custom qualities. Design for inconspicuous appearance and interaction with personal wearable thermal devices as well as focussed thermal comfort provision was further found to be key for social acceptability and for device use to integrate into the situational context.

10.4 Concluding Remarks

This thesis tried to challenge the way thermal comfort is commonly approached in research and practice, namely, from the top-down and based on the underlying assumption that individual thermal comfort perception can be sufficiently described by standards and norms. Instead, this thesis followed a bottom-up, design and user-centred approach that gave voice to the people, their perceived experiences and adaptive actions. Thus, this work uncovered the complexity inherent in the achievement of thermal comfort by the individual and the rich exploration, adaptation and appropriation processes taking place on environmental and personal scale, which dynamically transcend different layers of comfort needs. In as such, the approach followed in this thesis which will hopefully inspire future research in the field.

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Appendix A

Materials Pilot Survey

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A1. Questionnaire

PhD Student Comfort Survey – Questionnaire

This survey is part of PhD research on individual comfort in shared work environments in the Media and Arts Technology Programme, School of Electronic Engineering and Computer Science. It is intended to assess PhD students' individual comfort, their satisfaction with their workspace as well as the expectations they have in regard to their work environment. Your answers to the survey questions will help indicate the performance of current PhD workplaces and will provide us with an understanding of current problems affecting your individual comfort in your work environment. Your answers will furthermore feed into the development and design of portable and wearable interfaces and devices, which will help improve individual comfort in shared spaces.

This questionnaire is divided into 3 sections:

Section 1: Perceived Comfort

Section 2: Expectations

Section 3: Background Information

The survey is completed anonymously. It should take you approximately 10 to 15 minutes to answer the questionnaire. You are free to withdraw at any time without giving a reason by closing this website. Thank you very much in advance for taking the time to participate.

If you have any questions in regard to the survey or the related research, please feel free to contact:

Katja Knecht, k.knecht@gmul.ac.uk

Section 1: Perceived Comfort

In this section we are going to ask you about how comfortable you feel at the workplace you spend your time in.

Please let us know how satisfied you are with the following physical, climatic and social aspects of your work environment:

1.1. How satisfied are you with the **temperature** in your workspace?

Very Satisfied Satisfied Slightly Satisfied Neutral Slightly Dissatisfied Dissatisfied Very Dissatisfied

a If there are any issues affecting your satisfaction with the temperature in your work environment, please describe:

1.2. How satisfied are you with the **air quality** in your workspace (i.e. stuffy/stale air, cleanliness, odours)?

Very Satisfied Satisfied Slightly Satisfied Neutral Slightly Dissatisfied Dissatisfied Very Dissatisfied

a If there are any issues affecting your satisfaction with the air quality in your work environment, please describe:

1.3. How satisfied are you with the **amount of light** in your workspace?

Very Satisfied Satisfied Slightly Satisfied Neutral Slightly Dissatisfied Dissatisfied Very Dissatisfied

a If there are any issues affecting your satisfaction with the amount of light in your work environment, please describe:

1.4. How satisfied are you with the **visual comfort** of the lighting in your workspace? (e.g. glare, reflections, contrast)

Very Satisfied Satisfied Slightly Satisfied Neutral Slightly Dissatisfied Dissatisfied Very Dissatisfied

a If there are any issues affecting your satisfaction with the lighting conditions in your work environment, please describe:

1.5. How satisfied are you with the **visual contact** that you have with the exterior at your workspace? (e.g. number, size of and distance from the windows and outside view)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Satisfied	Satisfied	Slightly Satisfied	Neutral	Slightly Dissatisfied	Dissatisfied	Very Dissatisfied

a If there are any issues affecting your satisfaction with your visual contact with the exterior, please describe:

1.6. How satisfied are you with the **level of noise** in your workspace?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Satisfied	Satisfied	Slightly Satisfied	Neutral	Slightly Dissatisfied	Dissatisfied	Very Dissatisfied

a If there are any issues affecting your satisfaction with the level of noise in your workspace, please describe:

1.7. How satisfied are you with the **sound privacy** in your workspace? (e.g. ability to have conversations without your neighbours overhearing and vice versa)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Satisfied	Satisfied	Slightly Satisfied	Neutral	Slightly Dissatisfied	Dissatisfied	Very Dissatisfied

a If there are any issues affecting your satisfaction with the sound privacy in your workspace, please describe:

1.8. How satisfied are you with the **layout** of your workspace? (e.g. orientation of your desk, space available to you and distance to your neighbours)

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Satisfied	Satisfied	Slightly Satisfied	Neutral	Slightly Dissatisfied	Dissatisfied	Very Dissatisfied

a If there are any issues affecting your satisfaction with the layout of your workspace, please describe:

1.9. How satisfied are you with the level of **visual privacy** in your workspace?

Very Satisfied Satisfied Slightly Satisfied Neutral Slightly Dissatisfied Dissatisfied Very Dissatisfied

a If there are any issues affecting your satisfaction with the level of visual privacy in your workspace, please describe:

1.10. How satisfied are you with the **comfort and flexibility of your office furnishings?** (e.g. chair, desk, computer, equipment, etc.)

 Very Satisfied Satisfied Slightly Satisfied Neutral Slightly Dissatisfied Dissatisfied Very Dissatisfied

a If there are any issues affecting your satisfaction with the comfort of your office furnishing, please describe:

1.11. How satisfied are you with the **level of personal control** you have over your physical environment? (e.g. possibility to open windows, adjust temperature or light levels)

 Very Satisfied Satisfied Slightly Satisfied Neutral Slightly Dissatisfied Dissatisfied Very Dissatisfied

a If there are any issues affecting your satisfaction with the level of personal control available to you to change aspects of your physical work environment, please describe:

1.12. How satisfied are you with the **general cleanliness** of the work environment?

 Very Satisfied Satisfied Slightly Satisfied Neutral Slightly Dissatisfied Dissatisfied Very Dissatisfied

a If there are any issues affecting your satisfaction with the general cleanliness of the work environment, please describe:

1.13. How satisfied are you with the ease of **interaction with colleagues and fellow students?**

 Very Satisfied Satisfied Slightly Satisfied Neutral Slightly Dissatisfied Dissatisfied Very Dissatisfied

a If there are any issues affecting your satisfaction with the ease of interaction with your colleagues, please describe:

1.14. How satisfied are you with the general **work atmosphere** as you experience it?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Satisfied	Satisfied	Slightly Satisfied	Neutral	Slightly Dissatisfied	Dissatisfied	Very Dissatisfied

a If there are any issues affecting your satisfaction with the work atmosphere, please describe:

1.15. All things considered, how satisfied are you with your **personal workspace**?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Satisfied	Satisfied	Slightly Satisfied	Neutral	Slightly Dissatisfied	Dissatisfied	Very Dissatisfied

1.16. All things considered, how satisfied are you with the **general work environment**?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Satisfied	Satisfied	Slightly Satisfied	Neutral	Slightly Dissatisfied	Dissatisfied	Very Dissatisfied

1.17. Please tell us in your own words: what do you **like** about Queen Mary as a work environment? (e.g. in comparison to other places you know or have worked and studied at before)

1.18. Please tell us in your own words: what do you **dislike** about Queen Mary as a work environment? (e.g. in comparison to other places you know or have worked and studied at before)

1.19. Overall, does your work environment at Queen Mary **enhance** or **interfere** with your ability to get your work done?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Greatly Enhances	Enhances	Slightly Enhances	Neutral	Slightly Interferes	Interferes	Greatly Interferes

1.20. Please describe any other issues related to your comfort and well-being at Queen Mary that we have not addressed or that you would like to add:

Section 2: Expectations

In this section we are going to ask you about your minimum expectations in regard to different aspects of your workspace and work environment.

Please note: We are not asking you about your ideal workspace but about realistic expectations.

Please tell us how much you agree or disagree with the following statements:

2.1. The temperature in my workplace should be about the same all year around

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I strongly agree	I agree	I slightly agree	Neutral	I slightly disagree	I disagree	I strongly disagree

2.2. The temperature in my workplace should adapt to the temperatures outside

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I strongly agree	I agree	I slightly agree	Neutral	I slightly disagree	I disagree	I strongly disagree

2.3. The air in my workplace should not be stuffy

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I strongly agree	I agree	I slightly agree	Neutral	I slightly disagree	I disagree	I strongly disagree

2.4. My workplace should be well lit

2.5. The lighting in my workplace should not provide glare, reflections, or low contrast

2.6. I should be able to look outside from my workplace

2.7. My work environment should provide natural light

2.8. My work environment should be quiet

2.9. My work environment should allow me to have conversations without others overhearing and vice versa

2.10. My workplace should afford enough space and be well positioned in the shared space

2.11. My workplace should provide an undisturbed environment and not too many visual distractions

- 2.12. My workspace furnishings should be comfortable and flexible enough to adjust, rearrange or reorganise
- 2.13. I should be able to control climatic aspects of my local work environment, such as temperature, lighting and air flow, according to my needs
- 2.14. The work environment should be clean and tidy
- 2.15. The work environment should encourage interaction with my colleagues
- 2.16. The relationship among colleagues should be good
- 2.17. The general work atmosphere should be positive and supportive
- 2.18.
- 2.19. My work environment should support me in getting my work done
- 2.20. Are there any additional expectations that you have regarding your work environment that have not been mentioned or any aspects you would like to add? If so, please describe:

Section 3: Background Information

It will help us in further analysis if you would tell us a little about yourself and your workspace.

3.1. How many years have you been at Queen Mary?

- Less than a year
- 1 – 2 years
- 3 – 5 years
- More than 5 years

3.2. Do you have a desk allocated to you at Queen Mary?

- No
- Yes

If you **have a desk** allocated to you, please answer the following questions:

a Where is your desk situated?

- Computer Science Building, Room No.:
- Engineering Building, Room No.:
- Other, please describe:

If you **do not have a desk** allocated to you, please answer the following question:

b Where do you usually sit when you work on campus?

c How many people do you share this office or work space with?

3.3. For how long have you been working at your present allocated or chosen workspace?

- Less than 3 months
- 4-6 months
- 7-12 months
- More than 1 year

3.4. In a typical week, how many hours do you spend in your allocated or chosen workspace? (Please indicate approximate average not including time you spend away from it for, e.g. meetings, lab work, etc.)

- 10 or less
- 11-30
- More than 30

3.5. Are there any other spaces at Queen Mary that you use for your work and studies?

- No
- Yes. Please list (e.g. antennas' lab, performance lab, Mile End Library, etc.):

3.6. Which research group(s) do you belong to? (Please check all that apply)

- Antennas
- C4DM
- CogSci
- MMV
- Networks
- RIM
- Theory
- Computer Vision
- Other, please describe:

3.7. What is your age?

- 30 years or under
- 31 – 50 years
- Over 50 years

3.8. Where do you come from and which climate did you grow up in?

3.9. Have you lived outside the UK during the last 5 years?

- No
- Yes, please tell us where and for how long:

3.10. What is your gender?

- Female
- Male

As part of this research and subsequent to this study we are planning to conduct in depth interviews with students regarding their individual comfort at their workplaces at Queen Mary and are looking for volunteers. If you would be interested in participating in the follow-up study, please tick the box below and leave your name and email address. This information does not affect your answers to the questionnaire and will not be shared with third parties.

- I am interested in participating in the follow-up study and consent to be contacted for this purpose. I understand that my name and email will be stored solely to the purpose of contacting me on behalf of the follow-up study and that my details will not be shared with third parties.

Name:

Email:

Thank you very much for your participation!

Appendix B

Materials User Study Off-the-Shelf Devices

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B.1. Information Sheet



Information Sheet

Research study “Microatmospheres: Individual Comfort and Off-the-Shelf Personal Heating/Cooling Devices”: Information for Participants

We would like to invite you to be part of this research project, in which we are looking at people’s individual comfort in shared, open-plan work environments and at possibilities to improve it using personal heating and cooling devices. Please read the following information carefully before you decide to take part; this will tell you why the research is being done and what you will be asked to do if you take part. Please ask if there is anything that is not clear or if you would like more information.

If you do decide to take part you will be given this information sheet to keep and be asked to sign the attached consent form to say that you agree. You are still free to withdraw at any time and without giving a reason.

Comfort is a highly individual, dynamic and adaptive process. It is a state that evolves out of the lived and embodied experience of the human being in relation to his surrounding, overlaid by expectations, emotions and past experiences. In order to understand comfort it is consequently necessary to look at the individual and his/her perception of his/her environment as well as his/her behaviour within it.

This study is laid out accordingly and will consist of two parts. In the first part of this study, we will assess the overall conditions. We will ask you to fill out two comfort questionnaires and interview you on behalf of your experiences with and your perception of comfort in your workplace environment at the School of Electronic Engineering and Computer Science, Queen Mary University of London. This session will take about 30 minutes in total. The interview will be conducted in a mostly unstructured and open-ended manner but we might explicitly address issues of interest related to comfort or ask you to elaborate further on topics addressed by you in the questionnaire or during the interview itself.

In addition, we will install sensor nodes at your workspace, which will take the following environmental readings: temperature, humidity, light and sound levels, as well as air movement. The sensor nodes will stay installed throughout the whole study. As they are battery driven, we might have to access them every now and then for charging. Furthermore, we will take notes of any behaviours and adaptation processes taking place, with which you or other participants ensure comfort. Also, we might take thermal and regular images of your office and workplace to analyse its thermal and environmental properties.

During the second part of the study we would like you to fill out a questionnaire, which asks about your feeling of comfort “right now”, three times a day: 15 minutes after you have arrived in the office, about two hours later, and at the end of your working day, i.e. before you leave. We

would also like to ask you to put down in the comment section of the questionnaire any particular change of behaviour, perceptions or changes of comfort or discomfort you became aware of in relation to environmental changes, other people's actions or devices, any personal devices you use or your use of them. We will ask you to report on your comfort in this way for three working days.

Additional Information Off-the-Shelf Personal Heating/Cooling

If you have expressed interest in testing personal cooling/heating devices and if you do decide to take part, the devices will be given to you during the second part of the study. We will give you one of five different personal thermal devices at a time, which you can use during your working day to improve your thermal comfort. You will have the device at your disposal for three working days. During this time, we will ask you to fill out right now comfort questionnaires three times a day as described in the previous section. Furthermore, we will ask you to reflect on your use of and satisfaction with the device and fill out a very brief evaluation questionnaire at the end of the three working days.

This part of the study can consist of up to five episodes, one for each device. How many devices you test and episodes you complete is up to you. You can terminate this part of the study at any given point. However, to conclude the study we would like to get your overall feedback and hear about your experiences with the devices. We will ask you to fill out a short evaluation questionnaire and conduct a brief follow-up interview at the end.

The devices in question are:

For personal cooling:

Personal cooling fan, wrist cooler, ankle cooler, cooling body wrap, and cooling neck tie.

For personal heating:

Heated gloves, a heated shoulder pad, heated socks, a hot water bottle, and a personal fan heater.

You will be given a short introduction to the devices and health and safety instructions on how to use them at the beginning of an episode.

In general, we would like to state that you are not obliged to use the devices you are given and that you should only use them if you feel like using them and if you feel they will improve your comfort at a certain point in time. In addition, we would like to ask you to incorporate the devices into your working day but only to an extent, which is convenient and comfortable to you and causes the least possible disruption/interference with your daily routines.

If you have any questions, please let us know. If any questions should come up during the study, please do not hesitate to approach us in person or contact us by email.

All the information we collect about you during the course of the research will be kept strictly confidential. You will not be able to be identified in any reports or publications.

The audio recording of the interview as well as any pictures taken of you or your workplace will be used for analysis purposes only. No other use will be made of it without your written permission, and no one outside the project will be allowed access to the original recordings or image files.

It is entirely up to you to decide whether or not to take part. There are no disadvantages attached if, at any time, you choose not to take part or decide to withdraw from the study.

If you have any questions or concerns about the manner in which the study was conducted please, in the first instance, contact the researcher responsible for the study, Katja Knecht, on: k.knecht@qmul.ac.uk.

If this is unsuccessful, or not appropriate, please contact the Secretary at the Queen Mary Ethics of Research Committee, Room W117, Queen's Building, Mile End Campus, Mile End Road, London or research-ethics@qmul.ac.uk.

B.2. Questionnaires for Study on Heating Devices

Long-Term Comfort Survey

This survey is part of a PhD research in the Media and Arts Technology Programme, School of Electronic Engineering and Computer Science. It is intended to assess students' individual comfort, perceived performance and their satisfaction with their office space at QM. Your answers to the survey questions will help indicate the performance of the building's heating, ventilation, air conditioning, acoustical, lighting and cleaning systems, and will provide us with an understanding of current problems affecting individual comfort and with directions for possible improvements.

This survey is divided into 10 sections:

Section 1: Background information

Section 2: Workspace Location

Section 3: Furnishings

Section 4: Thermal Comfort

Section 5: Air Quality

Section 6: Lighting

Section 7: Outdoor and Indoor Visual Aspects

Section 8: Acoustic Quality

Section 9: Cleanliness and Maintenance

Section 10: General Comments

Thank you very much for your participation.

We will not store any personal data.

For questions please contact:

Katja Knecht, k.knecht@qmul.ac.uk

ID #

Section 1: Background Information

1.1. For how many years have you been working in your current office?

- Less than a year
- 1 – 2 years
- 3 – 5 years
- More than 5 years

1.2. How often do you work in your office during a regular working week (Monday to Friday)? (Please indicate approximate average)

- Every day
- Several days a week
- Once a week
- Less / never

1.3. How much time do you spend on average at your desk when you are in?

- Less than 30 minutes
- 30 min – 2 hours
- 2 hours – 4 hours
- 4 hours – 8 hours
- More than 8 hours

1.4. How do you usually use the facilities? (Please check all that apply)

- Research
- Meeting with others
- Other: _____

1.5. What is your age?

- 25 or under
- 26 – 35
- 36 – 45
- 46 – 55
- 56 - 65
- 65 or above

1.6. What is your current role?

- PhD Student
- Postdoc
- Researcher
- Other: _____

1.7. What is your gender?

- Female
- Male
- _____

ID #

Section 2: Workspace – Room Name

2.1. Do you usually sit next to an exterior wall?

- Yes
 No

2.2. Do you usually sit next to a window?

- Yes
 No

2.3. Which of the following best describes your workspace?

- Cubicle with high partitions (about 1.5m high)
 Cubicle with low partitions (lower than 1.5m high)
 Desk space in an open-plan office
 Other, please describe: _____

2.4. How many people do you share the office with?

2.5. How satisfied are you with the amount of space available for individual work?

-
- Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

a If you are dissatisfied with the amount of space available for individual work, which of the following contribute to your dissatisfaction? (Please check all that apply)

- Amount of work surface area
 Total area of work station
 Available space for personal items
 Other, please describe: _____

2.6. How satisfied are you with the level of visual privacy?

-
- Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

a If you are dissatisfied with the level of visual privacy, which of the following contribute to your dissatisfaction? (Please check all that apply)

- High density – too little space separating people
 Partitions or walls are too low, too transparent, or non-existent
 People can easily see in through interior/exterior windows or doors
 Too many people walking and passing by
 Other, please describe: _____

ID #

2.7. How satisfied are you with ease of interaction with colleagues and fellow students?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

Does not apply

2.8. Overall, does the workspace layout enhance or interfere with your ability to get your work done?

Greatly Interferes Interferes Slightly Interferes Neutral Slightly Enhances Enhances Greatly Enhances

2.9. Do you sometimes suffer from any of the following symptoms after having worked in your office? (Please check all that apply.)

- Headache
- Dizziness
- Nausea (feeling sick)
- Fatigue (extreme tiredness)
- Poor concentration
- Shortness of breath or chest tightness
- Eye and/or throat irritation
- Irritated, blocked or running nose
- Skin irritation (rashes, dry/itchy skin)
- Other, please describe: _____
- Do not want to say
- Does not apply

2.10. Please describe any other issues related to the office layout that are important to you.

Section 3: Furnishings

3.1. How satisfied are you with the comfort of the workspace furnishings (chair, desk, computer, equipment, etc.)?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

ID #

3.2. How satisfied are you with your ability to adjust the furniture to meet your needs?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

Does not apply

3.3. How satisfied are you with the colours and textures of flooring, furniture and surface finishes?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

3.4. Do your workspace furnishings enhance or interfere with your ability to get your work done?

Greatly Interferes Interferes Slightly Interferes Neutral Slightly Enhances Enhances Greatly Enhances

3.5. Please describe any other issues related to workspace furnishings that are important to you.

Section 4: Thermal Comfort

4.1. Which of the following can you personally adjust or control in your workspace? (Please check all that apply)

- Operable window
- Window blinds or shades
- Thermostat
- Portable heater
- Permanent heater
- Room air-conditioning unit
- Portable fan
- Adjustable air vent in wall or ceiling
- Adjustable floor air vent (diffuser)
- Door to interior space
- Door to exterior space
- None of the above
- Other, please describe: _____

ID

4.2. How satisfied are you with the temperature in your workspace?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

If you are dissatisfied with the temperature, which of the following contribute to your dissatisfaction?

a In warm/hot weather, the temperature in my workspace is: (Please check all that apply)

- Often too hot
- Often too cold
- I have not experienced a hot period in this room yet

b In warm/hot weather... (Please check all that apply)

- My hands are too cold
- My feet are too cold
- Other, please describe: _____

c In cool/cold weather, the temperature in my workspace is: (Please check all that apply)

- Often too hot
- Often too cold
- I have not experienced a cold period in this room yet

d In cool/cold weather... (Please check all that apply)

- My hands are too cold
- My feet are too cold
- Other, please describe: _____

e When is this most often a problem? (Please check all that apply)

- Morning (before 11am)
- Mid-day (11am – 2pm)
- Afternoon (2pm – 5pm)
- Evening (after 5pm)
- Weekends/holidays
- Monday mornings
- No particular time
- Other, please describe: _____

f How would you best describe the source of this discomfort? (Please check all that apply)

- Air movement too high (draughty)
- Air movement too low (stuffy)
- Drafts from windows
- Drafts from vents
- Drafts falling from the ceiling
- Heat from office equipment

ID #

- Heating/cooling system does not respond quickly enough to the thermostat
- Hot/cold floor surfaces
- Hot/cold ceiling surfaces
- Hot/cold wall surfaces
- Hot/cold window surfaces
- Humidity too high (damp)
- Humidity too low (dry)
- Incoming sun
- My area is hotter than other areas
- My area is colder than other areas
- Thermostat is inaccessible
- Thermostat is adjusted by other people
- Other, please describe: _____

g Please describe any other issues related to being too hot or too cold in your workspace

4.3. How satisfied are you with the level of personal control over your local thermal environment?

○ ○ ○ ○
| | | |
○ ○ ○ ○
| | | |
○ ○ ○ ○

Very Dissatisfied Slightly Neutral Slightly Satisfied Very
Dissatisfied Dissatisfied Dissatisfied Neutral Satisfied Satisfied Satisfied

a If you are dissatisfied with the level of personal control, what would you wish for?

4.4. Overall, does your thermal comfort in your workspace enhance or interfere with your ability to get your work done?

○ ○ ○ ○
| | | |
○ ○ ○ ○
| | | |
○ ○ ○ ○

Greatly Interferes Slightly Neutral Slightly Enhances Greatly
Interferes Interferes Interferes Neutral Enhances Enhances Enhances

ID #

Section 5: Air Quality

5.1. How satisfied are you with the air quality in your workspace (i.e. stuffy/stale air, cleanliness, odours)?

○ ○ ○ ○ ○ ○ ○

Very Dissatisfied Slightly Neutral Slightly Satisfied Very

Dissatisfied Dissatisfied Dissatisfied Neutral Satisfied Satisfied Satisfied

If you are dissatisfied with the air quality in your workspace, please rate the level of each of the following problems:

a Air is stuffy/stale

Minor problem ○ ○ ○ ○ ○ ○ ○ Major problem

Not a problem

b Air is not clean

Minor problem ○ ○ ○ ○ ○ ○ ○ Major problem

Not a problem

c Air smells bad (odours)

Minor problem ○ ○ ○ ○ ○ ○ ○ Major problem

Not a problem

d If there is an odour problem, which of the following contribute to this problem? (Please check all that apply)

- Carpet or furniture
- Cleaning products
- Food
- Other people
- Outside sources (car exhaust, smog, tobacco smoke)
- Perfume
- Printer
- Other, please describe: _____

5.2. Which of the following exists in your workspace to increase the air quality? (Please check all that apply)

- Operable windows
- Room ventilation unit
- Adjustable personal vents
- Other, please describe: _____

ID #

5.2. How satisfied are you with the level of personal control over the indoor air quality?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

a If you are dissatisfied with the level of personal control, what would you wish for?

5.3. Overall, does the air quality in your workspace enhance or interfere with your ability to get your work done?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Greatly Interferes	Interferes	Slightly Interferes	Neutral	Slightly Enhances	Enhances	Greatly Enhances

5.4. Please describe any other issues related to the air quality in your workspace that are important to you.

Section 6: Lighting

6.1. Which of the following controls do you have over the lighting in your workspace? (Please check all that apply)

- Desk (task) light
- Light dimmer
- Light switch
- Window blinds or shades
- None of the above
- Other, please describe: _____

6.2. How satisfied are you with the amount of light in your workspace?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

ID #

6.3. How satisfied are you with the visual comfort of the lighting (e.g., glare reflections, contrast)?

○ ○ ○ ○ ○ ○ ○

| | | | | | |

○ ○ ○ ○ ○ ○ ○

Very Dissatisfied Slightly Neutral Slightly Satisfied Very

Dissatisfied Dissatisfied Dissatisfied Neutral Satisfied Satisfied Satisfied

a If you are dissatisfied with the lighting in your workspace, which of the following contribute to your dissatisfaction? (Please check all that apply)

- Electric lighting flickers
- Electric lighting is an undesirable colour
- Not enough daylight
- Too much daylight
- Not enough electric lighting
- Too much electric lighting
- Too dark
- Too bright
- No task lighting
- Reflections in the computer screen
- Shadows on the workspace
- Other, please describe: _____

6.4. How satisfied are you with the level of personal control over the lighting in your workspace?

○ ○ ○ ○ ○ ○ ○

| | | | | | |

○ ○ ○ ○ ○ ○ ○

Very Dissatisfied Slightly Neutral Slightly Satisfied Very

Dissatisfied Dissatisfied Dissatisfied Neutral Satisfied Satisfied Satisfied

a If you are dissatisfied with the level of personal control, what would you wish for?

6.4. Overall, does the lighting quality enhance or interfere with your ability to get your work done?

○ ○ ○ ○ ○ ○ ○

| | | | | | |

○ ○ ○ ○ ○ ○ ○

Greatly Interferes Slightly Neutral Slightly Enhances Greatly

Interferes Interferes Interferes Neutral Enhances Enhances Enhances

6.5. Please describe any other issues related to lighting that are important to you.

ID #

Section 7: Outdoor and Indoor Visual Aspects

7.1. How satisfied are you with the view of the outside that you have at your workspace?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

7.2. How satisfied are you with the visual contact that you have with nature from the exterior at your workspace?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

7.3. How satisfied are you with the view that you have of plants in the interior at your workspace?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

a If you are dissatisfied with the visual contact with plants in your environment, what would you wish for?

7.4. Overall, does your view of the outside, nature and plants at your workspace enhance or interfere with your ability to get your work done?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Greatly Interferes	Interferes	Slightly Interferes	Neutral	Slightly Enhances	Enhances	Greatly Enhances

7.5. Please describe any other issues related to visual contact and its quality that are important to you.

ID #

Section 8: Acoustic Quality

8.1. How satisfied are you with the noise level in your workspace?

○ ○ ○ ○ ○ ○ ○

| | | | | | |

○ ○ ○ ○ ○ ○ ○

Very Dissatisfied Slightly Neutral Slightly Satisfied Very

Dissatisfied Dissatisfied Dissatisfied Neutral Satisfied Satisfied Satisfied

a If you are dissatisfied with the acoustics in your workspace, which of the following contribute to this problem? (Please check all that apply)

- Echoing of voices or other sounds
- Mechanical noise (heating, cooling and ventilation system)
- Mobile phones ringing
- Noise from lighting
- Office equipment noise
- Outdoor traffic noise
- Other outdoor noise
- People talking on the phone
- People talking in neighbouring areas
- Other, please describe: _____

8.2. How satisfied are you with the sound privacy in your workspace (ability to have conversations without your neighbours overhearing and vice versa)?

○ ○ ○ ○ ○ ○ ○

| | | | | | |

○ ○ ○ ○ ○ ○ ○

Very Dissatisfied Slightly Neutral Slightly Satisfied Very

Dissatisfied Dissatisfied Dissatisfied Neutral Satisfied Satisfied Satisfied

8.3. How often do you wear headphones at your desk when you work? (Please check the one that applies)

- Always
- Very often
- Sometimes
- Rarely
- Never

a If you wear headphones, what are your main reasons for using them? (Please check the ones that apply)

- Work-related
- Not to disturb others while listening to music
- Not to disturb others while watching videos
- To reduce/cancel out environmental noise
- Other, please describe: _____

ID #

8.4. Overall, does the acoustic quality in your workspace enhance or interfere with your ability to get your work done?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Greatly Interferes	Interferes	Slightly Interferes	Neutral	Slightly Enhances	Enhances	Greatly Enhances

8.5. Please describe any other issues related to acoustics that are important to you.

Section 9: Cleanliness and Maintenance

9.1. How satisfied are you with general cleanliness of the overall building?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

9.2. How satisfied are you with cleaning service provided for workspaces?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

a If you are dissatisfied with the cleaning service provided for workspaces, how often do you encounter significant problems?

- Always
- Often
- Sometimes
- Rarely
- Never
- Don't know

b Which of the following contribute to this dissatisfaction? (Please check all that apply)

- Bathrooms are messy/dirty
- Common utility areas are unkempt (e.g., copy/print areas cluttered with paper/waste)
- Desk surfaces are dusty/dirty
- Entrances, lobby and other communal spaces are unkempt
- Floors are dirty
- Walls and windows are dirty
- Waste baskets and bins are not emptied often enough
- Other, please describe: _____

ID #

9.3. Does the cleanliness and maintenance of this building enhance or interfere with your ability to get your work done?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Greatly Interferes	Interferes	Slightly Interferes	Neutral	Slightly Enhances	Enhances	Greatly Enhances

9.4. Please describe any other issues related to cleaning and maintenance that are important to you.

Section 10: General Comments

10.1. All things considered, how satisfied are you with your workspace?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

10.2. Please estimate how much you think your productivity is increased or decreased by the environmental conditions in this building (e.g. thermal, lighting, acoustics, cleanliness):

Decreased	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Increased
	-20%	-10%	-5%	0%	+5%	+10%	+20%

10.3. How satisfied are you with the building overall?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

10.4. Do you sometimes work in another place because of issues with your workplace comfort? If so, please tell us where and why.

10.4. Any additional comments or recommendations you would like to give on behalf of your office space or the building overall?

Thank you for your participation!

Right Now Survey

The following questions refer to the current conditions and the level of comfort as you perceive it at the time you answer this questionnaire. Please reply accordingly and tell us how you feel right now.

Date: _____ Time: _____

1. How would you describe the weather outside? (Please check all that apply)

- | | | | |
|--|----------------------------------|--------------------------------------|---------------------------------|
| <input type="checkbox"/> Clear/sunny | <input type="checkbox"/> Drizzly | <input type="checkbox"/> Foggy/misty | <input type="checkbox"/> Other: |
| <input type="checkbox"/> Partly cloudy | <input type="checkbox"/> Rainy | <input type="checkbox"/> Windy | |
| <input type="checkbox"/> Cloudy/Grey | <input type="checkbox"/> Snowy | <input type="checkbox"/> Stormy | |

2. How do you feel right now?

- | | | | | | | |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Cold | Cool | Slightly Cool | Neutral | Slightly Warm | Warm | Hot |

3. Would you like to be

- Cooler
- No change
- Warmer

4. How acceptable is the room temperature to you?

- | | | | | | | |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Very Unacceptable | Unacceptable | Slightly Unacceptable | Neutral | Slightly Acceptable | Acceptable | Very Acceptable |

a. If you are dissatisfied, how would you best describe the source of your discomfort?

- Air movement too high / too low (please underline the one that applies)
- Incoming sun
- Drafts from windows / vents (please underline the one that applies)
- Hot / cold surrounding surfaces: floor, ceiling, walls or windows (please underline the one that applies)
- Heating system provides too much / not enough heat (please underline the one that applies)
- Personal heating device provides too much / not enough heat (please underline the one that applies)
- Other, please describe: _____

5. How would you describe your activity level just prior to completing this survey?

- Seated
- Standing (relaxed)
- Light activity, standing
- Medium activity, standing
- High activity, walking

6. Did you spend the past 30 minutes prior to completing this survey in this office?

- Yes
- No, please describe which kind of environment you have been in, e.g. outside or inside the building:

If you spent the past 30 minutes in this office, did you use the personal heating device?

- Yes
- No

7. Did you eat or drink anything during the past 30 minutes prior to completing this survey?

- Yes, please describe and please also state if what you ate or drank was hot, cold, or at room temperature:

- No

8. Please tell us if you changed any layers of your clothing:

- I am wearing the same as before (no change)
- I added (please specify):

- I removed (please specify):

- Other:

9. Do you have any additional comments regarding the current thermal conditions or your comfort?

Right Now Survey - Clothing

To better be able to assess your individual comfort based on your survey answers and in regard to your workplace climate, it would help us if you let us know which layers and type of clothes you are wearing during the day. Please fill this out once at the beginning of the day and indicate in subsequent questionnaires if you have made any changes to your clothing.

Date: _____

Please indicate which of the following layers of clothing you are wearing right now:

Layers and Type of Clothing	Light weight	Medium weight	Heavy weight
a Base layers/underwear	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b Mid layer	Light weight	Medium weight	Heavy weight
Short sleeved shirt/top	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Long sleeved shirt/top	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Trousers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Shorts/Skirt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dress (women)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tights (women)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Socks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c Outer layer	Light weight	Medium weight	Heavy weight
Sweater	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Vest	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Jacket	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Footwear	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scarf	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wrap/shawl	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hat/cap	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

ID #

2. Did you notice any difference in regard to your feeling of thermal comfort having the device around?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
Colder	Cooler	Slightly Cooler	No change	Slightly Warmer	Warmer	Hot	Too Hot

4. Please let us know, how much you agree or disagree with the following statements:

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Doesn't apply
a	I like having the device.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
b	The device provides relief from feeling cold.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
c	The device does not provide enough heat.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
d	The device gives more individual control.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
e	The device disrupted my work.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
f	I find the device comfortable to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
g	I find the device inconvenient to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>

5. Is there anything you particularly liked about the device, which you would like to let us know about?

ID #

6. Is there anything you particularly disliked about the device, which you would like to let us know about?

7. Do you have any suggestions for alterations in regard to how the device works and how it is controlled? If so, please let us know.

8. Do you have any additional comments about the device or any other issues we have not addressed yet?

Thank you very much for your participation!

ID #

End of Study Evaluation Questionnaire

In the following questionnaire we would like you to give us a brief, summarised evaluation of the personal heating devices used during this study.

1. Which of the personal heating devices did you actively use during the study? (Please check all that apply)

- Heated Gloves
- Heated Shoulder Pad
- Heated Socks
- Hot Water Bottle
- Personal Fan Heater

2. Which of the devices, if any, did you like using the most? (Please explain briefly why)

3. Which of the devices, if any, did you like using the least? (Please explain briefly why)

4. Which of the devices, if any, did you find most useable and convenient in your work environment? (Please explain briefly why)

ID #

5. Please let us know, how comfortable heating on the following body areas felt to you:

		Very Uncomfortable	Uncomfortable	Neutral	Comfortable	Very Comfortable	Doesn't apply
a	Neck and Shoulder Area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
b	Back	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
c	Hands	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
d	Belly and Mid Body Area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
e	Lower Legs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
f	Feet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>

6. If you could design your own personal heating device – what would it be like or what would you wish for?

7. Do you have any additional comments about the personal heating devices used in this study that have not yet been covered?

7. Do you have any feedback in regard to how this study was conducted?

Thank you very much for your participation!

B.3. Questionnaires for Study on Cooling Devices

Long-Term Comfort Survey

This survey is part of a PhD research in the Media and Arts Technology Programme, School of Electronic Engineering and Computer Science. It is intended to assess students' individual comfort, perceived performance and their satisfaction with their office space at QM. Your answers to the survey questions will help indicate the performance of the building's heating, ventilation, air conditioning, acoustical, lighting and cleaning systems, and will provide us with an understanding of current problems affecting individual comfort and with directions for possible improvements.

This survey is divided into 10 sections:

Section 1: Background information

Section 2: Workspace Location

Section 3: Furnishings

Section 4: Thermal Comfort

Section 5: Air Quality

Section 6: Lighting

Section 7: Outdoor and Indoor Visual Aspects

Section 8: Acoustic Quality

Section 9: Cleanliness and Maintenance

Section 10: General Comments

Thank you very much for your participation.

We will not store any personal data.

For questions please contact:

Katja Knecht, k.knecht@qmul.ac.uk

ID #

Section 1: Background Information

1.1. For how many years have you been working in your current office?

- Less than a year
- 1 – 2 years
- 3 – 5 years
- More than 5 years

1.2. How often do you work in your office during a regular working week (Monday to Friday)? (Please indicate approximate average)

- Every day
- Several days a week
- Once a week
- Less / never

1.3. How much time do you spend on average at your desk when you are in?

- Less than 30 minutes
- 30 min – 2 hours
- 2 hours – 4 hours
- 4 hours – 8 hours
- More than 8 hours

1.4. How do you usually use the facilities? (Please check all that apply)

- Research
- Meeting with others
- Other: _____

1.5. What is your age?

- 25 or under
- 26 – 35
- 36 – 45
- 46 – 55
- 56 - 65
- 65 or above

1.6. What is your current role?

- PhD Student
- Postdoc
- Researcher
- Other: _____

1.7. What is your gender?

- Female
- Male
- _____

ID #

Section 2: Workspace – Room Name

2.1. Do you usually sit next to an exterior wall?

- Yes
 No

2.2. Do you usually sit next to a window?

- Yes
 No

2.3. Which of the following best describes your workspace?

- Cubicle with high partitions (about 1.5m high)
 Cubicle with low partitions (lower than 1.5m high)
 Desk space in an open-plan office
 Other, please describe: _____

2.4. How many people do you share the office with?

2.5. How satisfied are you with the amount of space available for individual work?

-
- Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

a If you are dissatisfied with the amount of space available for individual work, which of the following contribute to your dissatisfaction? (Please check all that apply)

- Amount of work surface area
 Total area of work station
 Available space for personal items
 Other, please describe: _____

2.6. How satisfied are you with the level of visual privacy?

-
- Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

a If you are dissatisfied with the level of visual privacy, which of the following contribute to your dissatisfaction? (Please check all that apply)

- High density – too little space separating people
 Partitions or walls are too low, too transparent, or non-existent
 People can easily see in through interior/exterior windows or doors
 Too many people walking and passing by
 Other, please describe: _____

ID #

2.7. How satisfied are you with ease of interaction with colleagues and fellow students?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

Does not apply

2.8. Overall, does the workspace layout enhance or interfere with your ability to get your work done?

Greatly Interferes Interferes Slightly Interferes Neutral Slightly Enhances Enhances Greatly Enhances

2.9. Do you sometimes suffer from any of the following symptoms after having worked in your office? (Please check all that apply.)

- Headache
- Dizziness
- Nausea (feeling sick)
- Fatigue (extreme tiredness)
- Poor concentration
- Shortness of breath or chest tightness
- Eye and/or throat irritation
- Irritated, blocked or running nose
- Skin irritation (rashes, dry/itchy skin)
- Other, please describe: _____
- Do not want to say
- Does not apply

2.10. Please describe any other issues related to the office layout that are important to you.

Section 3: Furnishings

3.1. How satisfied are you with the comfort of the workspace furnishings (chair, desk, computer, equipment, etc.)?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

ID #

3.2. How satisfied are you with your ability to adjust the furniture to meet your needs?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

Does not apply

3.3. How satisfied are you with the colours and textures of flooring, furniture and surface finishes?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

3.4. Do your workspace furnishings enhance or interfere with your ability to get your work done?

Greatly Interferes Interferes Slightly Interferes Neutral Slightly Enhances Enhances Greatly Enhances

3.5. Please describe any other issues related to workspace furnishings that are important to you.

Section 4: Thermal Comfort

4.1. Which of the following can you personally adjust or control in your workspace? (Please check all that apply)

- Operable window
- Window blinds or shades
- Thermostat
- Portable heater
- Permanent heater
- Room air-conditioning unit
- Portable fan
- Adjustable air vent in wall or ceiling
- Adjustable floor air vent (diffuser)
- Door to interior space
- Door to exterior space
- None of the above
- Other, please describe: _____

ID #

4.2. How satisfied are you with the temperature in your workspace?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

If you are dissatisfied with the temperature, which of the following contribute to your dissatisfaction?

a In warm/hot weather, the temperature in my workspace is: (Please check all that apply)

- Often too hot
- Often too cold
- I have not experienced a hot period in this room yet

b In warm/hot weather... (Please check all that apply)

- My hands are too cold
- My feet are too cold
- Other, please describe: _____

c In cool/cold weather, the temperature in my workspace is: (Please check all that apply)

- Often too hot
- Often too cold
- I have not experienced a cold period in this room yet

d In cool/cold weather... (Please check all that apply)

- My hands are too cold
- My feet are too cold
- Other, please describe: _____

e When is this most often a problem? (Please check all that apply)

- Morning (before 11am)
- Mid-day (11am – 2pm)
- Afternoon (2pm – 5pm)
- Evening (after 5pm)
- Weekends/holidays
- Monday mornings
- No particular time
- Other, please describe: _____

f How would you best describe the source of this discomfort? (Please check all that apply)

- Air movement too high (draughty)
- Air movement too low (stuffy)
- Drafts from windows
- Drafts from vents
- Drafts falling from the ceiling
- Heat from office equipment

ID #

- Heating/cooling system does not respond quickly enough to the thermostat
- Hot/cold floor surfaces
- Hot/cold ceiling surfaces
- Hot/cold wall surfaces
- Hot/cold window surfaces
- Humidity too high (damp)
- Humidity too low (dry)
- Incoming sun
- My area is hotter than other areas
- My area is colder than other areas
- Thermostat is inaccessible
- Thermostat is adjusted by other people
- Other, please describe: _____

g Please describe any other issues related to being too hot or too cold in your workspace

4.3. How satisfied are you with the level of personal control over your local thermal environment?

○ ○ ○ ○
| | | |
○ ○ ○ ○
| | | |
○ ○ ○ ○

Very Dissatisfied Slightly Neutral Slightly Satisfied Very
Dissatisfied Dissatisfied Dissatisfied Neutral Satisfied Satisfied Satisfied

a If you are dissatisfied with the level of personal control, what would you wish for?

4.4. Overall, does your thermal comfort in your workspace enhance or interfere with your ability to get your work done?

○ ○ ○ ○
| | | |
○ ○ ○ ○
| | | |
○ ○ ○ ○

Greatly Interferes Slightly Neutral Slightly Enhances Greatly
Interferes Interferes Interferes Neutral Enhances Enhances Enhances

ID #

Section 5: Air Quality

5.1. How satisfied are you with the air quality in your workspace (i.e. stuffy/stale air, cleanliness, odours)?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

If you are dissatisfied with the air quality in your workspace, please rate the level of each of the following problems:

a Air is stuffy/stale

Minor problem Major problem

Not a problem

b Air is not clean

Minor problem Major problem

Not a problem

c Air smells bad (odours)

Minor problem Major problem

Not a problem

d If there is an odour problem, which of the following contribute to this problem? (Please check all that apply)

- Carpet or furniture
- Cleaning products
- Food
- Other people
- Outside sources (car exhaust, smog, tobacco smoke)
- Perfume
- Printer
- Other, please describe: _____

5.2. Which of the following exists in your workspace to increase the air quality? (Please check all that apply)

- Operable windows
- Room ventilation unit
- Adjustable personal vents
- Other, please describe: _____

ID #

5.2. How satisfied are you with the level of personal control over the indoor air quality?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

a If you are dissatisfied with the level of personal control, what would you wish for?

5.3. Overall, does the air quality in your workspace enhance or interfere with your ability to get your work done?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Greatly Interferes	Interferes	Slightly Interferes	Neutral	Slightly Enhances	Enhances	Greatly Enhances

5.4. Please describe any other issues related to the air quality in your workspace that are important to you.

Section 6: Lighting

6.1. Which of the following controls do you have over the lighting in your workspace? (Please check all that apply)

- Desk (task) light
- Light dimmer
- Light switch
- Window blinds or shades
- None of the above
- Other, please describe: _____

6.2. How satisfied are you with the amount of light in your workspace?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

ID #

6.3. How satisfied are you with the visual comfort of the lighting (e.g., glare reflections, contrast)?

○ ○ ○ ○ ○ ○ ○

| | | | | | |

○ ○ ○ ○ ○ ○ ○

Very Dissatisfied Slightly Neutral Slightly Satisfied Very

Dissatisfied Dissatisfied Dissatisfied Neutral Satisfied Satisfied Satisfied

a If you are dissatisfied with the lighting in your workspace, which of the following contribute to your dissatisfaction? (Please check all that apply)

- Electric lighting flickers
- Electric lighting is an undesirable colour
- Not enough daylight
- Too much daylight
- Not enough electric lighting
- Too much electric lighting
- Too dark
- Too bright
- No task lighting
- Reflections in the computer screen
- Shadows on the workspace
- Other, please describe: _____

6.4. How satisfied are you with the level of personal control over the lighting in your workspace?

○ ○ ○ ○ ○ ○ ○

| | | | | | |

○ ○ ○ ○ ○ ○ ○

Very Dissatisfied Slightly Neutral Slightly Satisfied Very

Dissatisfied Dissatisfied Dissatisfied Neutral Satisfied Satisfied Satisfied

a If you are dissatisfied with the level of personal control, what would you wish for?

6.4. Overall, does the lighting quality enhance or interfere with your ability to get your work done?

○ ○ ○ ○ ○ ○ ○

| | | | | | |

○ ○ ○ ○ ○ ○ ○

Greatly Interferes Slightly Neutral Slightly Enhances Greatly

Interferes Interferes Interferes Neutral Enhances Enhances Enhances

6.5. Please describe any other issues related to lighting that are important to you.

ID #

Section 7: Outdoor and Indoor Visual Aspects

7.1. How satisfied are you with the view of the outside that you have at your workspace?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

7.2. How satisfied are you with the visual contact that you have with nature from the exterior at your workspace?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

7.3. How satisfied are you with the view that you have of plants in the interior at your workspace?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

a If you are dissatisfied with the visual contact with plants in your environment, what would you wish for?

7.4. Overall, does your view of the outside, nature and plants at your workspace enhance or interfere with your ability to get your work done?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Greatly Interferes	Interferes	Slightly Interferes	Neutral	Slightly Enhances	Enhances	Greatly Enhances

7.5. Please describe any other issues related to visual contact and its quality that are important to you.

ID #

Section 8: Acoustic Quality

8.1. How satisfied are you with the noise level in your workspace?

○ ○ ○ ○ ○ ○ ○

| | | | | | |

○ ○ ○ ○ ○ ○ ○

Very Dissatisfied Slightly Neutral Slightly Satisfied Very
Dissatisfied Dissatisfied Dissatisfied Neutral Satisfied Satisfied Satisfied

a If you are dissatisfied with the acoustics in your workspace, which of the following contribute to this problem? (Please check all that apply)

- Echoing of voices or other sounds
- Mechanical noise (heating, cooling and ventilation system)
- Mobile phones ringing
- Noise from lighting
- Office equipment noise
- Outdoor traffic noise
- Other outdoor noise
- People talking on the phone
- People talking in neighbouring areas
- Other, please describe: _____

8.2. How satisfied are you with the sound privacy in your workspace (ability to have conversations without your neighbours overhearing and vice versa)?

○ ○ ○ ○ ○ ○ ○

| | | | | | |

○ ○ ○ ○ ○ ○ ○

Very Dissatisfied Slightly Neutral Slightly Satisfied Very
Dissatisfied Dissatisfied Dissatisfied Neutral Satisfied Satisfied Satisfied

8.3. How often do you wear headphones at your desk when you work? (Please check the one that applies)

- Always
- Very often
- Sometimes
- Rarely
- Never

a If you wear headphones, what are your main reasons for using them? (Please check the ones that apply)

- Work-related
- Not to disturb others while listening to music
- Not to disturb others while watching videos
- To reduce/cancel out environmental noise
- Other, please describe: _____

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8.4. Overall, does the acoustic quality in your workspace enhance or interfere with your ability to get your work done?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Greatly Interferes	Interferes	Slightly Interferes	Neutral	Slightly Enhances	Enhances	Greatly Enhances

8.5. Please describe any other issues related to acoustics that are important to you.

Section 9: Cleanliness and Maintenance

9.1. How satisfied are you with general cleanliness of the overall building?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

9.2. How satisfied are you with cleaning service provided for workspaces?

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very Dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Satisfied	Satisfied	Very Satisfied

a If you are dissatisfied with the cleaning service provided for workspaces, how often do you encounter significant problems?

- Always
- Often
- Sometimes
- Rarely
- Never
- Don't know

b Which of the following contribute to this dissatisfaction? (Please check all that apply)

- Bathrooms are messy/dirty
- Common utility areas are unkempt (e.g., copy/print areas cluttered with paper/waste)
- Desk surfaces are dusty/dirty
- Entrances, lobby and other communal spaces are unkempt
- Floors are dirty
- Walls and windows are dirty
- Waste baskets and bins are not emptied often enough
- Other, please describe: _____

ID #

9.3. Does the cleanliness and maintenance of this building enhance or interfere with your ability to get your work done?

Greatly Interferes Interferes Slightly Interferes Neutral Slightly Enhances Enhances Greatly Enhances

9.4. Please describe any other issues related to cleaning and maintenance that are important to you.

Section 10: General Comments

10.1. All things considered, how satisfied are you with your workspace?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

10.2. Please estimate how much you think your productivity is increased or decreased by the environmental conditions in this building (e.g. thermal, lighting, acoustics, cleanliness):

Decreased Increased

-20% -10% -5% 0% +5% +10% +20%

10.3. How satisfied are you with the building overall?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

10.4. Do you sometimes work in another place because of issues with your workplace comfort? If so, please tell us where and why.

10.4. Any additional comments or recommendations you would like to give on behalf of your office space or the building overall?

Thank you for your participation!

Thermal Background Questionnaire

In the following questionnaire we would like to get to know about your individual thermal background and what you usually do to achieve thermal comfort at home and in the office.

Section 1: Individual Thermal Background

- 1.1. How would you describe the climate you grew up or spent most of your life in?

- 1.2. For how long have you been living in London and how does its climate affect you (if at all)?

- 1.3. Would you call yourself a person that can easily feel cold, or can easily feel too warm, or neither?

Section 2: Behavioural Adjustments

- 2.1. What do you do or how do you adjust to the temperature if you feel cold? *(Please let us know briefly for each case if applicable which devices you use, if you put on/off specific clothing, if you make adjustments to the environment, or if you notice any behavioural changes happening about yourself)*
 - a At home

b In the office

2.2. What do you do or how do you adjust to the temperature if you feel hot? *(Please let us know briefly for each case if applicable which devices you use, if you put on/off specific clothing, if you make adjustments to the environment, or if you notice any behavioural changes happening about yourself)*

a At home

b In the office

2.3. What from your point of view is the greatest challenge you face in achieving thermal comfort in your workplace?

Thank you very much for your participation!

Right Now Survey

The following questions refer to the current conditions and the level of comfort as you perceive it at the time you answer this questionnaire. Please reply accordingly and tell us how you feel right now.

Date: _____ Time: _____

1. How would you describe the weather outside? (Please check all that apply)

- Clear/sunny Drizzly Foggy/misty Other:
- Partly cloudy Rainy Windy
- Cloudy/Grey Snowy Stormy

2. How do you feel right now?

- Cold Cool Slightly Cool Neutral Slightly Warm Warm Hot

3. Would you like to be

- Cooler
- No change
- Warmer

4. How acceptable is the room temperature to you?

- Very Unacceptable Unacceptable Slightly Unacceptable Neutral Slightly Acceptable Acceptable Very Acceptable

a. If you are dissatisfied, how would you best describe the source of your discomfort?

- Air movement too high / too low (please underline the one that applies)
- Incoming sun
- Drafts from windows / vents (please underline the one that applies)
- Hot / cold surrounding surfaces: floor, ceiling, walls or windows (please underline the one that applies)
- Heating / Cooling system provides too much / not enough heating / cooling (please underline the one that applies)
- Personal cooling device provides too much / not enough cooling (please underline the one that applies)
- Other, please describe: _____

5. How would you describe your activity level just prior to completing this survey?

- Seated
- Standing (relaxed)
- Light activity, standing
- Medium activity, standing
- High activity, walking

6. Did you spend the past 30 minutes prior to completing this survey in this office?

- Yes
- No, please describe which kind of environment you have been in, e.g. outside or inside the building:

If you spent the past 30 minutes in this office, did you use the personal cooling device?

- Yes
- No

7. Did you eat or drink anything during the past 30 minutes prior to completing this survey?

- Yes, please let us know what temperature what you ate or drank was at:
 - Hot Room temperature Cold
- No

8. Please tell us if you changed any layers of your clothing:

- I am wearing the same as before (no change)
- I added (please specify): _____
- I removed (please specify): _____
- Other: _____

9. Do you have any additional comments regarding the current thermal conditions or your comfort?

Right Now Survey - Clothing

To better be able to assess your individual comfort based on your survey answers and in regard to your workplace climate, it would help us if you let us know which layers and type of clothes you are wearing during the day. Please fill this out once at the beginning of the day and indicate in subsequent questionnaires if you have made any changes to your clothing.

Date: _____

Please indicate which of the following layers of clothing you are wearing right now:

Layers and Type of Clothing	Light weight	Medium weight	Heavy weight
a Base layers/underwear	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b Mid layer	Light weight	Medium weight	Heavy weight
Short sleeved shirt/top	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Long sleeved shirt/top	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Trousers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Shorts/Skirt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dress (women)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tights (women)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Socks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c Outer layer	Light weight	Medium weight	Heavy weight
Sweater	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Vest	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Jacket	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Footwear	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scarf	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wrap/shawl	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hat/cap	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Evaluation Questionnaire: «Device1»

In the following questionnaire we would like to hear about your use of the «Device1» during the past three working days. We would like to know how satisfied and comfortable you were using it and if it made a difference to your thermal comfort.

1. Did you use the «Device1»?

- Yes (more than one day)
- I started but stopped using it
- No

If you did use the device, please answer the following questions:

- a When and how often did you approximately use it? (Please indicate, for example, whether there were specific times you used it)

- b In what ways, if any, did you adapt to using the «Device1» during the last three days? Did it, for example change the way you dressed or sat on your chair?

- c When you were not working or sitting at your desk but somewhere else instead, did you notice any difference? Did you, for example, wish you could take the «Device1» with you?

If you did not use the «Device1» during this period, please let us know why:

2. Did you notice any difference in regard to your feeling of thermal comfort having the «Device1» around?

3. How did having the «Device1» make you feel in general compared to not having the device?

<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Too Cold	Colder	Cooler	Slightly Cooler	No change	Slightly Warmer	Warmer	Hot

4. Please let us know how comfortable cooling felt to you on the following body areas: (Please only provide a rating for the body areas you used the device on)

	Very Uncomfortable	Uncomfortable	Neutral	Comfortable	Very Comfortable	Doesn't apply
a Neck and Shoulder Area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
b Back	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
c Hands	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
d Belly and Mid Body Area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
e Lower Legs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
f Feet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>

5. Please let us know, how much you agree or disagree with the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Doesn't apply
a I like having the «Device1».	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
b The «Device1» provides relief from feeling hot.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
c The «Device1» does not provide enough cooling.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
d The «Device1» gives more individual control.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
e The «Device1» disrupted my work.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
f I find the «Device1» comfortable to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
g I find the «Device1» inconvenient to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>

ID #

End of Study Evaluation Questionnaire

In the following questionnaire we would like you to give us a brief, summarised evaluation of the personal cooling devices used during this study.

1. Which of the personal cooling devices did you actively use during the study? (Please check all that apply)

- Wrist Coolers
- Cooling Neck Tie
- Cooling Body Wrap
- Ankle Coolers
- Personal Cooling Fan

2. Which of the devices, if any, did you like using the most? (Please explain briefly why)

3. Which of the devices, if any, did you like using the least? (Please explain briefly why)

4. Which of the devices, if any, did you find most useable and convenient in your work environment? (Please explain briefly why)

5. Did you use any additional devices during the study besides the one(s) we provided or did you adjust your clothing or the environment when you felt too hot or too cold? (In case you did, please let us know briefly which and how)

ID #

6. Please let us know, how comfortable cooling on the following body parts feels to you in general:

		Very Uncomfortable	Uncomfortable	Neutral	Comfortable	Very Comfortable	Doesn't apply
a	Neck and Shoulder Area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
b	Back	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
c	Hands	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
d	Belly and Mid Body Area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
e	Lower Legs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
f	Feet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>

7. If you could design your own personal cooling device – what would it be like or what would you wish for?

8. Do you have any additional comments about the personal cooling devices used in this study that have not yet been covered?

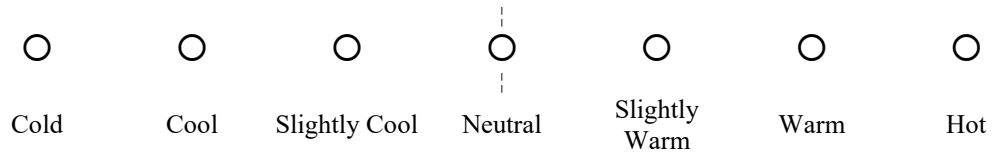
9. Do you have any feedback in regard to how this study was conducted?

Thank you very much for your participation!

B.4. Right-Now Survey Plots of Study on Heating Devices

Answers to the following questions are depicted in the graphs:

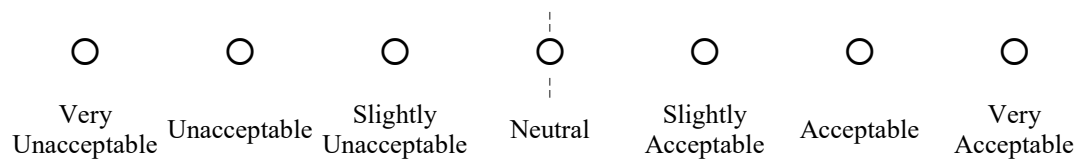
1. How do you feel right now?



2. Would you like to be

- Cooler
- No change
- Warmer

3. How acceptable is the temperature to you?

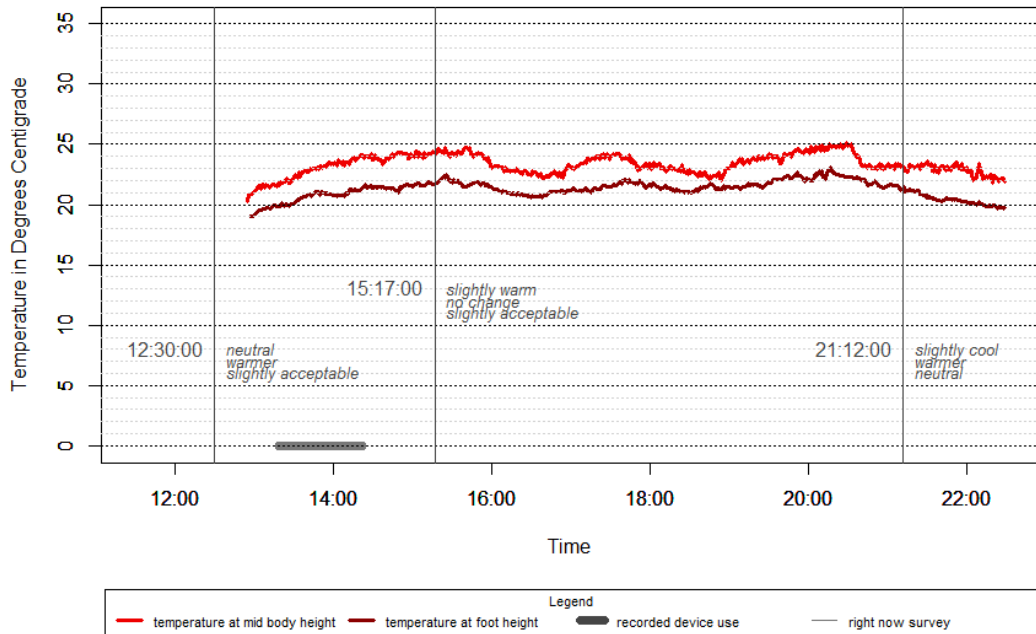


Participant H1

Personal Fan Heater

H1 – Personal Fan Heater, DAY 1

H1 - Personal Fan Heater, Day 1



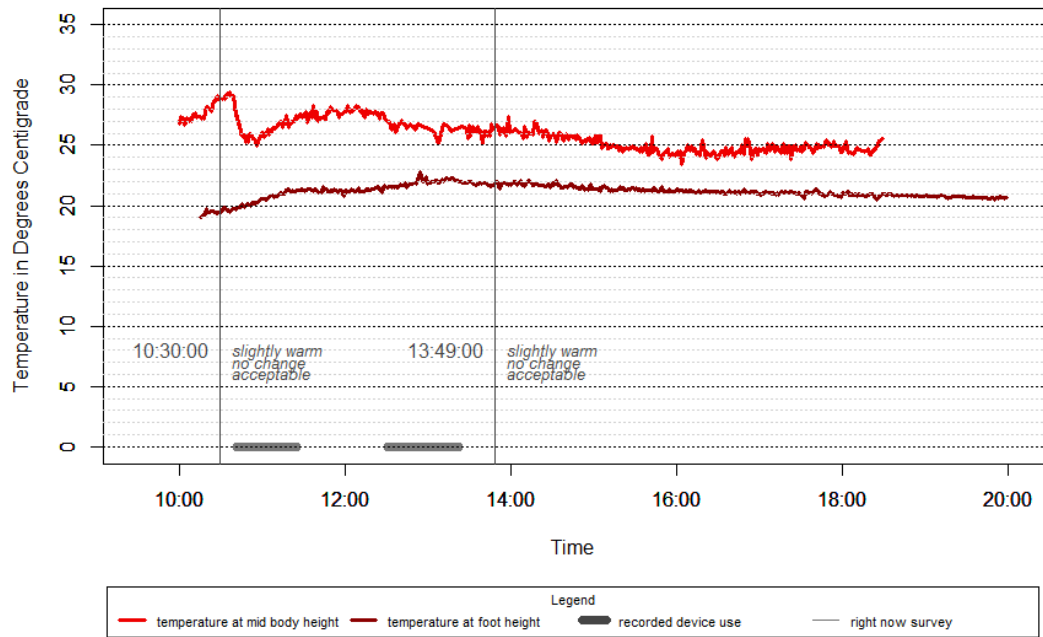
Outdoor Weather	Cloudy/Grey
Clothing	Light-weight base layer, short sleeved shirt, medium-weight trousers, sweater;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:30	Light activity, standing, 1.4 met	Heating system does not provide enough heat		
15:17	Seated, 1.0 met			Used fan heater, removed shoes
21:12	Seated, 1.0 met	Draft from windows		Used fan heater, removed shoes

Comment	“I cannot tune the personal heating device properly: it is too hot and makes it difficult to breathe.”
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H1 – Personal Fan Heater, DAY 2

H1 - Personal Fan Heater, Day 2

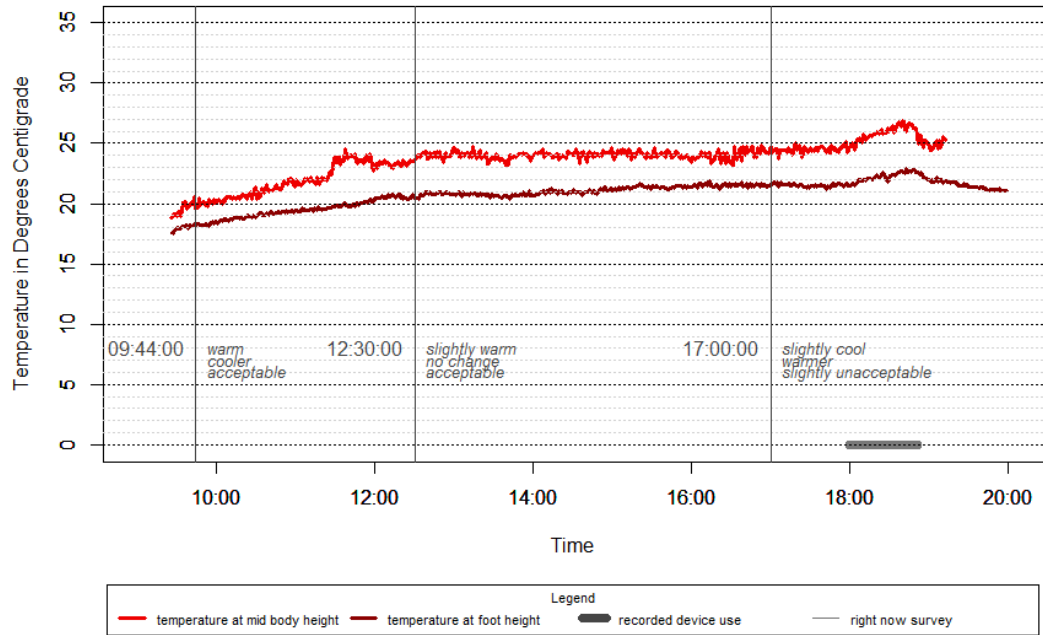


Outdoor Weather	Clear/sunny
Clothing	Light-weight base layer, short-sleeved shirt, medium-weight trousers, sweater;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:30	High activity, walking, 2.0 met			Removed shoes
13:49	Seated, 1.0 met			

H1 – Personal Fan Heater, DAY 3

H1 - Personal Fan Heater, Day 3



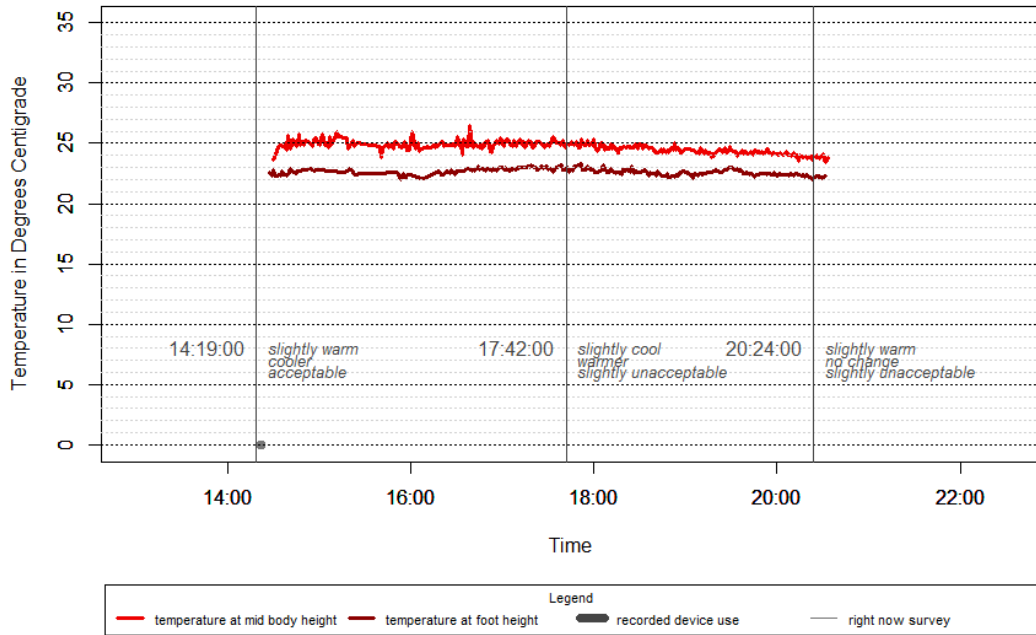
Outdoor Weather	Cloudy/grey to partly cloudy to clear/sunny
Clothing	Light-weight long-sleeved shirt, medium-weight base layer, trousers, socks, sweater;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:44	medium activity, standing, 1.7 met			
12:30	Seated, 1.0 met			
17:00	Seated, 1.0 met	Air movement too high, drafts from windows		Added hood to the sweater

Heated Socks

H1 – Heated Socks, DAY 1

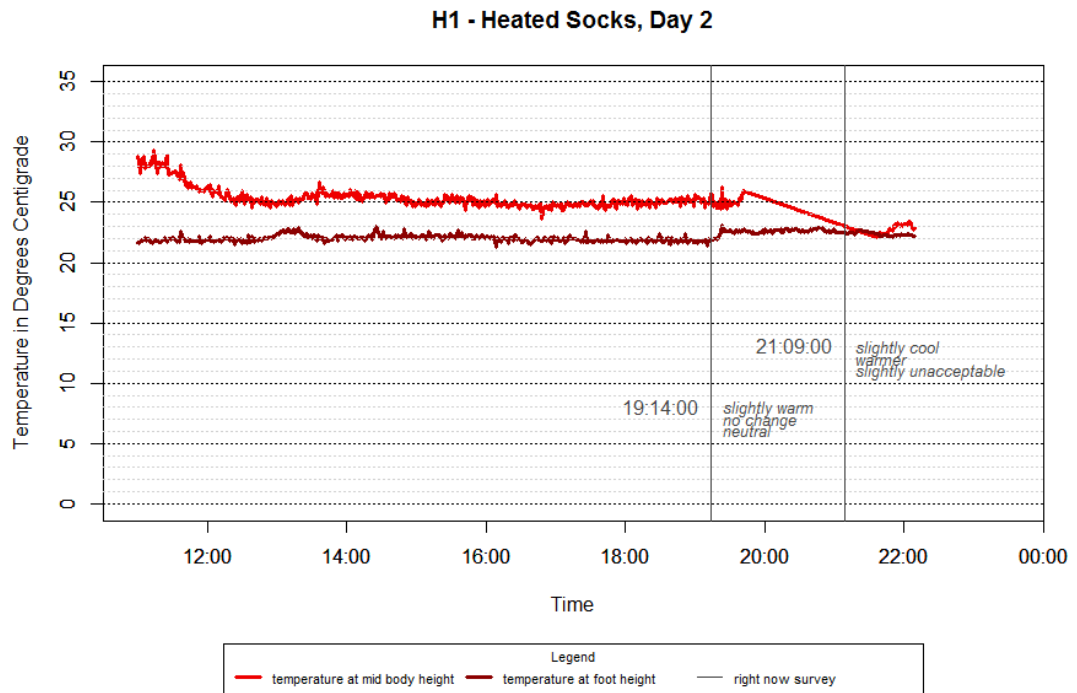
H1 - Heated Socks, Day 1



Outdoor Weather	Clear/sunny and windy
Clothing	Light-weight base layer, short-sleeved shirt, socks medium-weight trousers; no shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
14:19	Medium activity, standing, 1.7 met			
17:42	Seated, 1.0 met	Air movement too high		
20:24	Seated, 1.0 met	Heating system provides not enough heat		Socks in the shoes but turned off; added shoes

H1 – Heated Socks, DAY 2

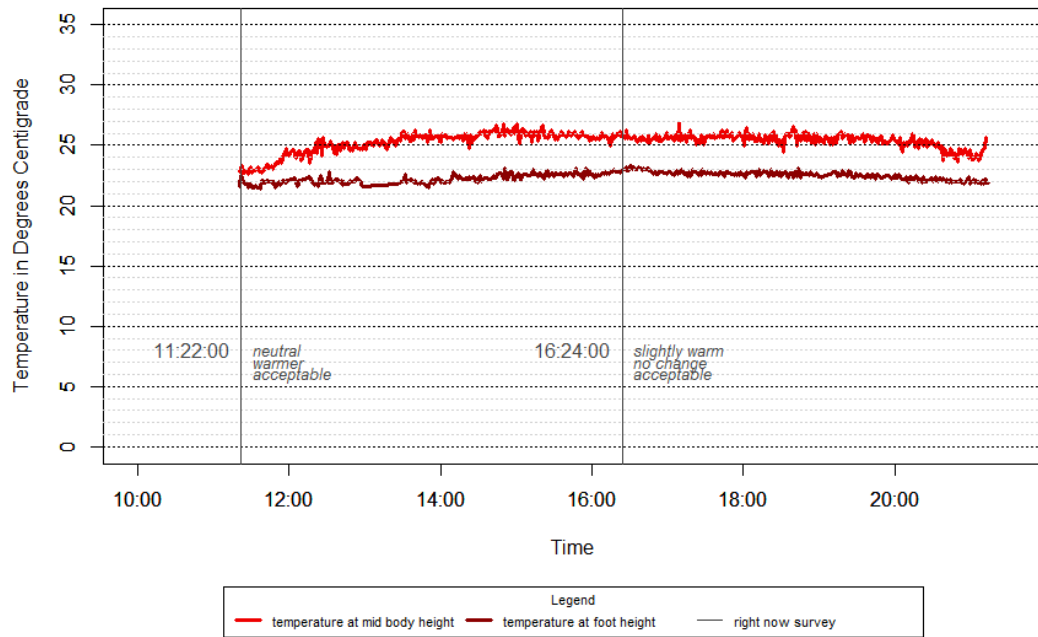


Outdoor Weather	Clear/sunny and windy
Clothing	Light-weight base layer, short-sleeved shirt, socks medium-weight trousers, sweater;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
19:14	Light activity, standing, 1.4 met			
21:09	Seated, 1.0 met	Air movement too high, drafts from windows, heating system provides not enough heat,		Used heated socks but provide not enough heat, added one more jumper;

H1 – Heated Socks, DAY 3

H1 - Heated Socks, Day 3



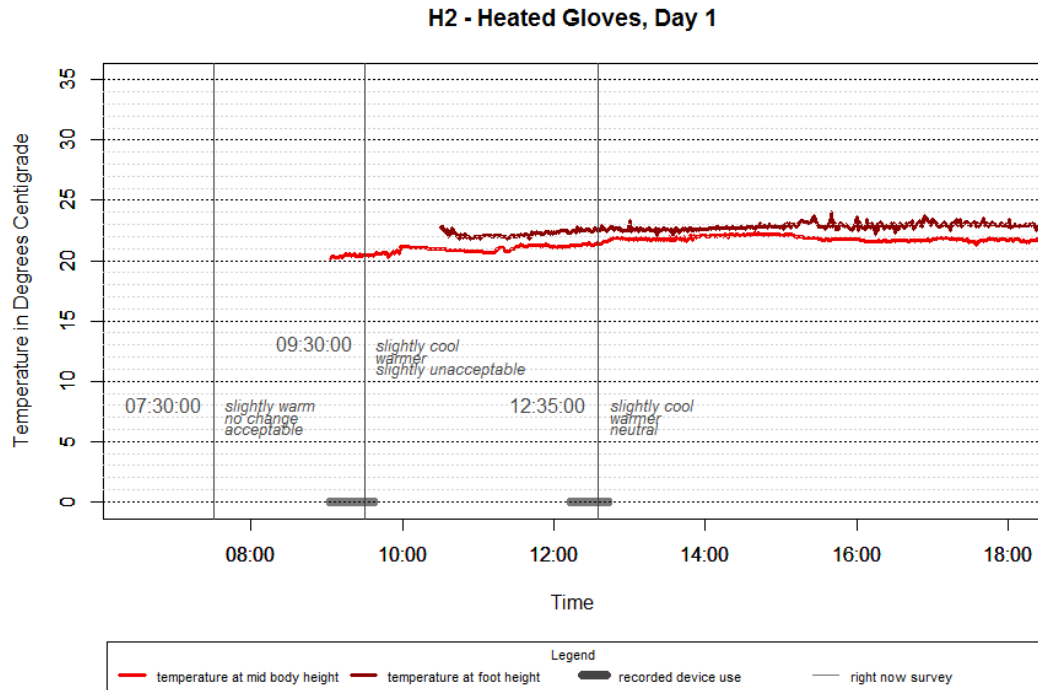
Outdoor Weather	Partly cloudy to clear/sunny
Clothing	Light-weight base layer, short-sleeved shirt, socks medium-weight trousers;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:22	Standing, relaxed, 1.2 met			
16:24	Light activity, standing, 1.4 met			Added sweater

Participant H2

Heated Gloves

H2 – Heated Gloves, DAY 1

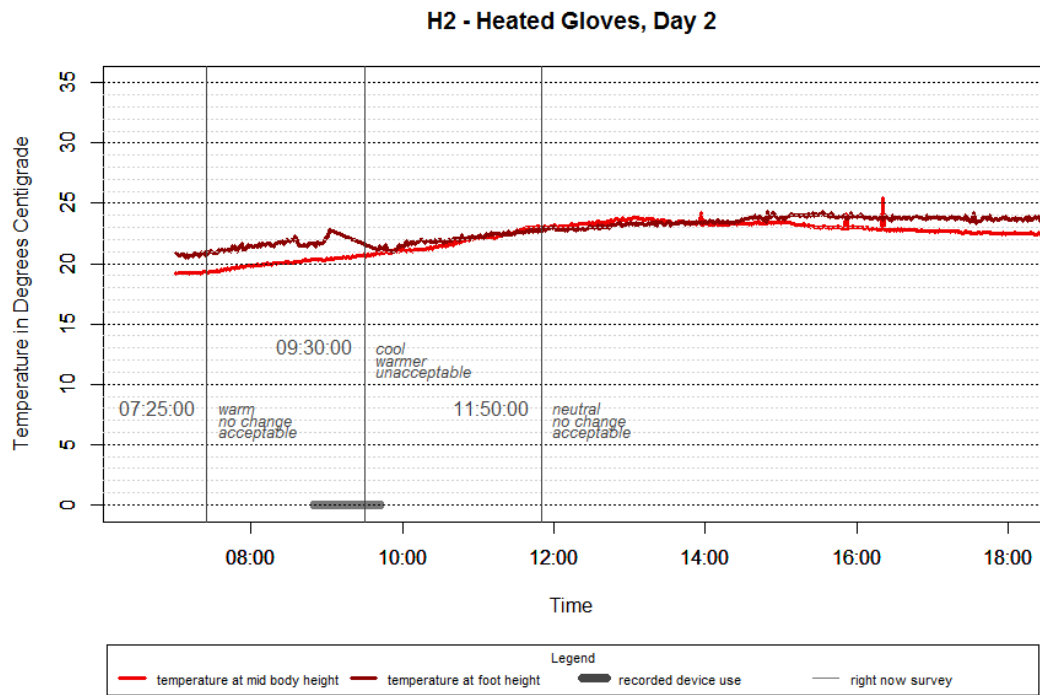


Outdoor Weather	Cloudy/grey, drizzly, and foggy/misty to partly cloudy
Clothing	Medium-weight base layer, short-sleeved shirt, long-sleeved shirt, trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
07:30	High activity, walking, 2.0 met			
09:30	Seated, 1.0 met	Heating system provides not enough heat,		Used heated gloves, “just chilly & want to put a scarf on!”
12:35	Seated, 1.0 met		At room temperature	Used heated gloves

Comments	(1) “Day 1 with gloves and concerned the cables & control will really annoy me as they drag on the table making a noise.” (3) “Again putting gloves on highlighted my neck was cold.”
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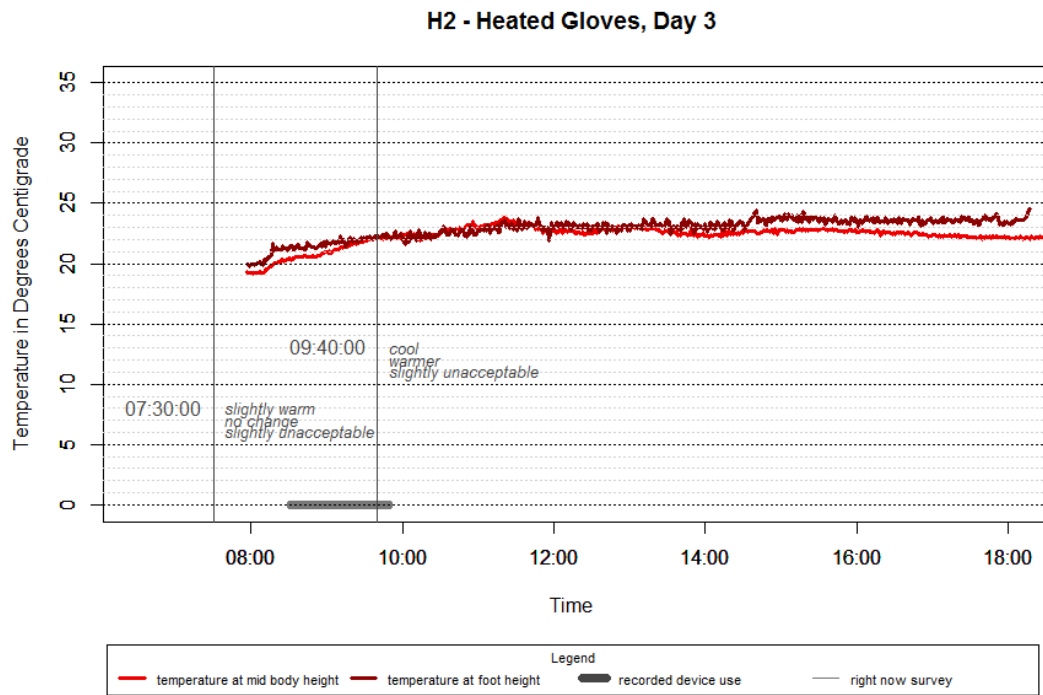
H2 – Heated Gloves, DAY 2



Outdoor Weather	Partly cloudy
Clothing	Medium-weight base layer, short-sleeved shirt, long-sleeved shirt, trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
07:25	High activity, walking, 2.0 met			
09:30	Seated, 1.0 met	Heating system provides not enough heat	At room temperature	Used heated gloves, added a scarf
19:50	Seated, 1.0 met			Removed scarf

H2 – Heated Gloves, DAY 3



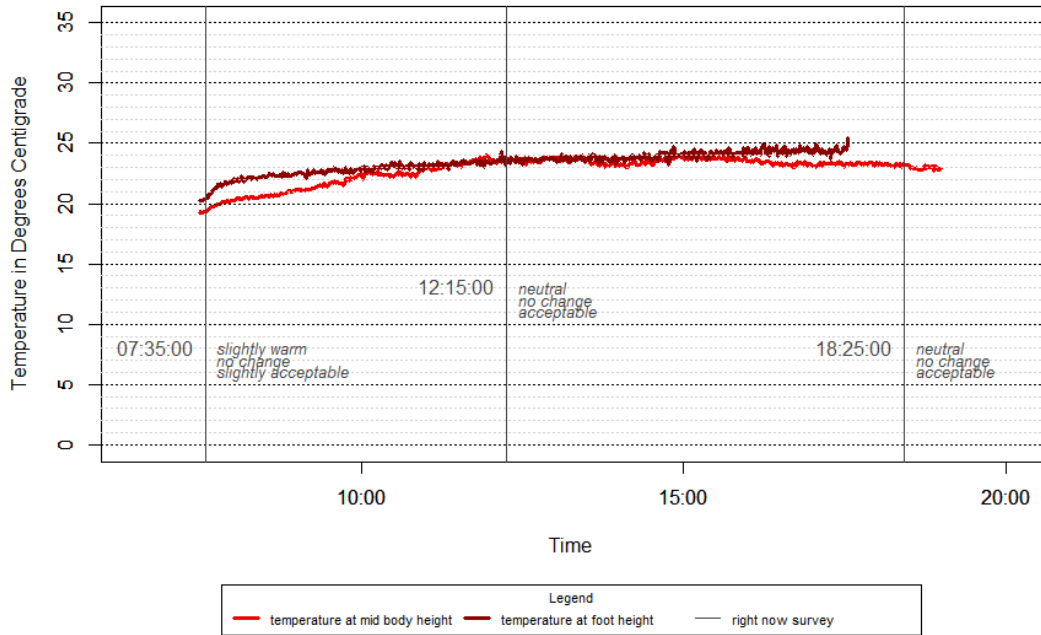
Outdoor Weather	Partly cloudy
Clothing	Medium-weight base layer, short-sleeved shirt, trousers, socks, sweater;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
07:30	High activity, walking, 2.0 met	Cold surrounding surfaces		
09:40	Seated, 1.0 met	Cold surrounding surfaces, heating system provides not enough heat	At room temperature	Used heated gloves, added a scarf

Hot Water Bottle

H2 – Hot Water Bottle, DAY 1

H2 - Hot Water Bottle, Day 1

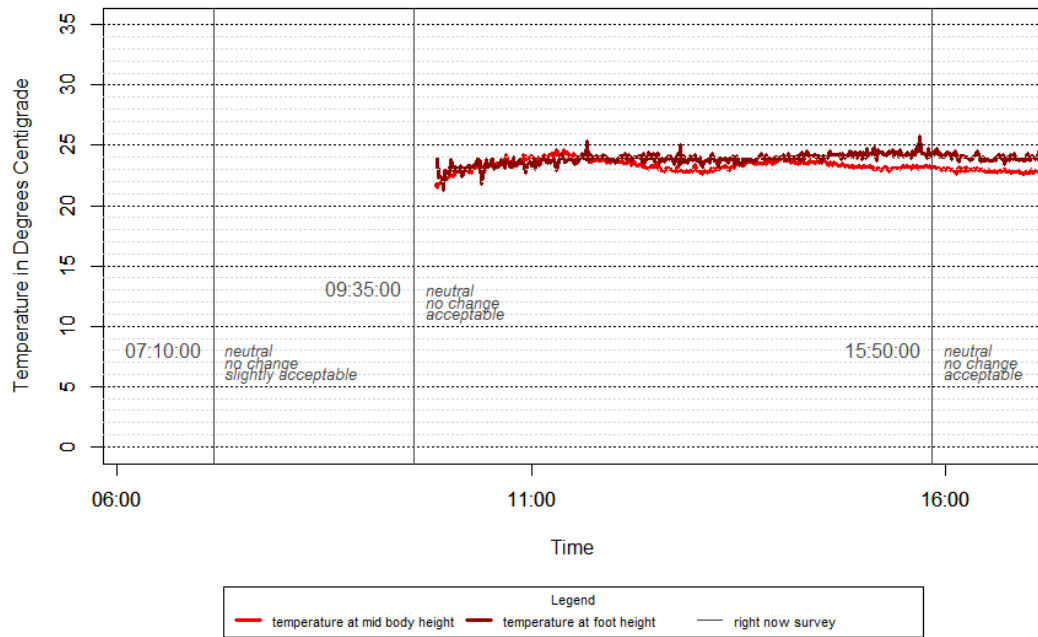


Outdoor Weather	Partly cloudy to clear/sunny
Clothing	Medium-weight base layer, long-sleeved shirt, trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
07:35	High activity, walking, 2.0 met			
12:15	Seated, 1.0 met		At room temperature	
18:25	Seated, 1.0 met		At room temperature	

H2 – Hot Water Bottle, DAY 2

H2 - Hot Water Bottle, Day 2

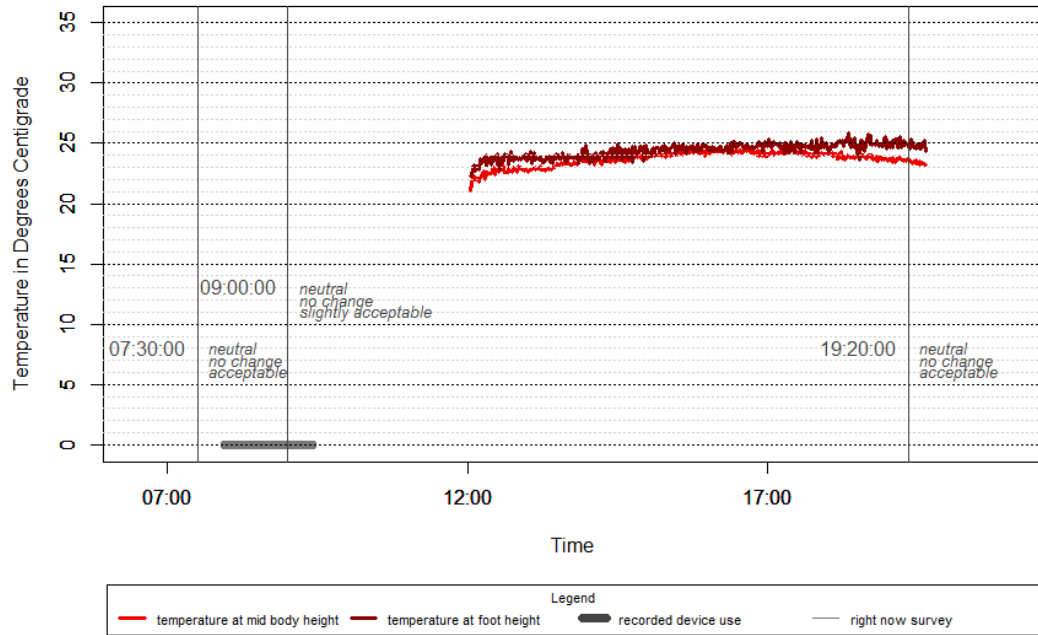


Outdoor Weather	Partly cloudy to clear/sunny to partly cloudy
Clothing	Medium-weight base layer, long-sleeved shirt, trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
07:10	High activity, walking, 2.0 met			
09:35	Seated, 1.0 met		At room temperature	
15:50	Medium activity, standing, 1.7 met		At room temperature	

H2 – Hot Water Bottle, DAY 3

H2 - Hot Water Bottle, Day 3



Outdoor Weather	Partly cloudy to cloudy/grey
Clothing	Medium-weight base layer, short-sleeved shirt, trousers, sweater;

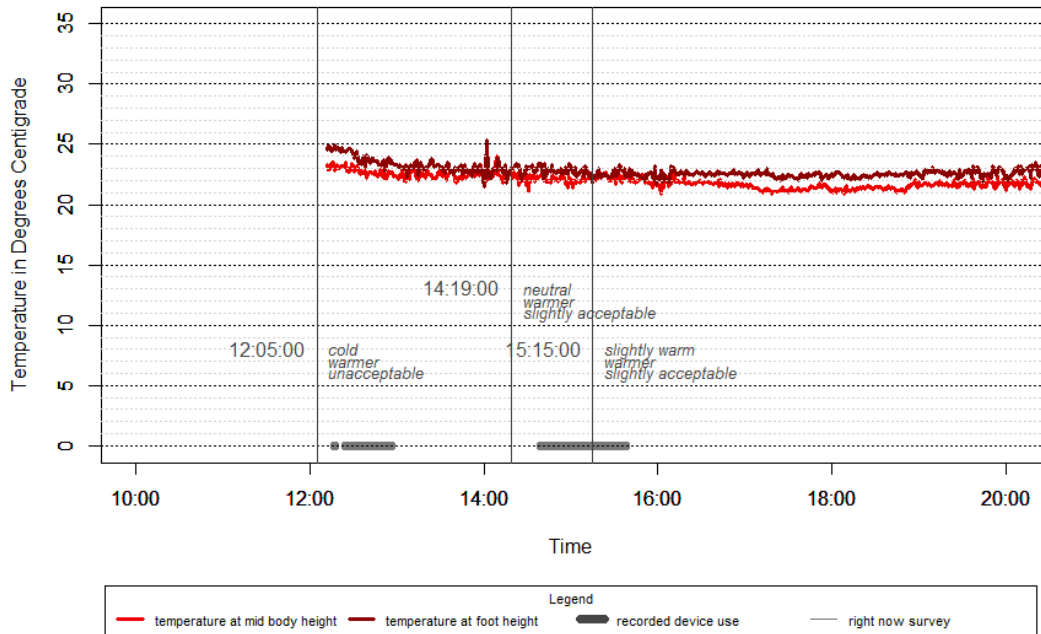
Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
07:30	Seated, 1.0 met			
09:00	Seated, 1.0 met		At room temperature	Used hot water bottle
19:20	Light activity, standing, 1.4 met		At room temperature	

Participant H3

Heated Shoulder Pad

H3 – Heated Shoulder Pad, DAY 1

H3 - Heated Shoulder Pad, Day 1



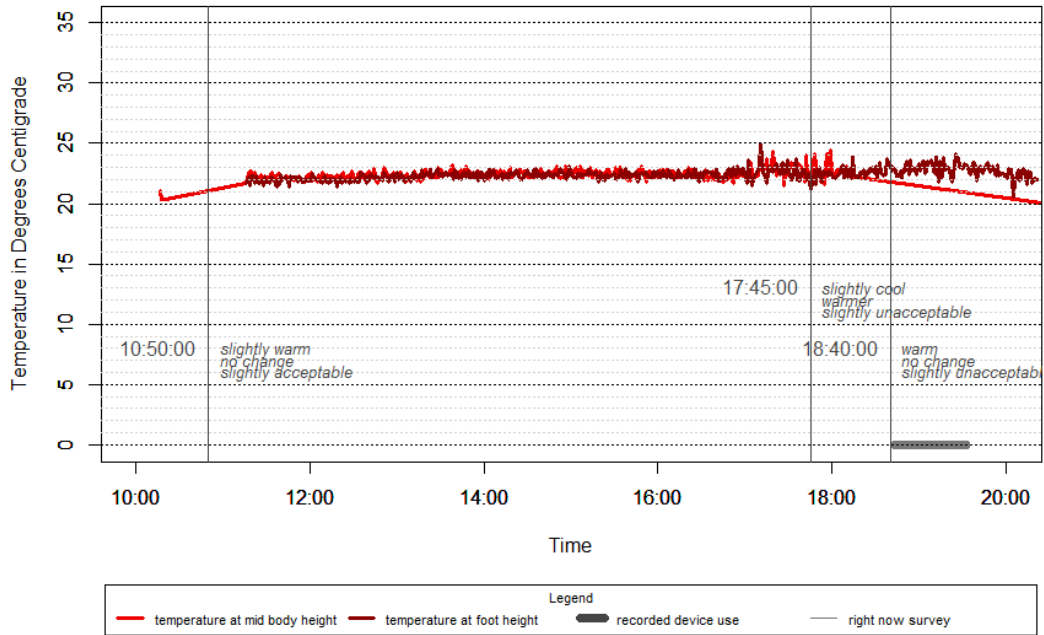
Outdoor Weather	Clear/sunny
Clothing	Medium-weight base layer, long-sleeved shirt, trousers, socks, heavy-weight jacket

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:05	Seated, 1.0 met	Drafts from windows, cold surrounding walls and windows, heating system does not provide enough heat, personal heating device does not provide enough heat		Added a thick, heavy-weight jacket
14:19	Seated, 1.0 met	Drafts from windows, cold surrounding walls and windows, heating system does not provide enough heat, personal heating device does not	Sip of water and sandwich	Used shoulder pad

		provide enough heat		
15:15	Seated, 1.0 met	Drafts from windows, cold surrounding walls and windows, heating system does not provide enough heat, personal heating device does not provide enough heat	A glass of water	Used shoulder pad

Comments	(2) "I'm feeling less uncomfortable then the past 2 hours due to the wearing of the shoulder pad, heating number 1." (3) "The shoulder pad really keeps me warm. I'm used to it now I think I'll wear it tomorrow."
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H3 - Heated Shoulder Pad, Day 2



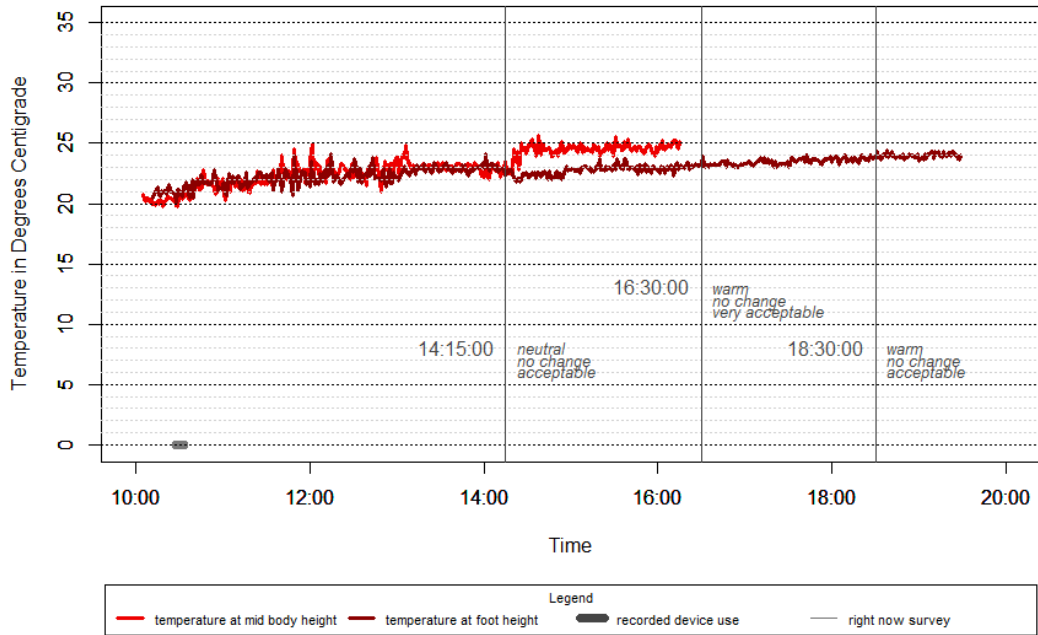
Outdoor Weather	Cloudy/grey to foggy/misty and dark
Clothing	Medium-weight base layer, short-sleeved shirt, heavy-weight long-sleeved shirt, trousers, socks, sweater, scarf

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:50	Seated, 1.0 met	Drafts from windows, cold surrounding walls and windows, heating system does not provide enough heat, personal heating device does not provide enough heat		
17:45	Seated, 1.0 met	Drafts from windows, cold surrounding walls and windows, heating system does not provide enough heat, personal heating device does not provide enough heat	Hot	
18:40	Seated, 1.0 met	Drafts from windows, cold	Hot	Used shoulder pad on legs,

		surrounding walls and windows, heating system does not provide enough heat, personal heating device does not provide enough heat		added a thick jacket
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Comments	(1) "I'm not wearing the shoulder pad as planned but will see if I'll need to in the next hour. I think the central heating produces higher room temperature today compared to yesterday or maybe I feel less cold than yesterday because of I'm wearing thicker clothing than yesterday."
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H3 - Heated Shoulder Pad, Day 3



Outdoor Weather	Clear/sunny
Clothing	Light-weight base layer, socks, medium-weight short-sleeved shirt, trousers, vest;

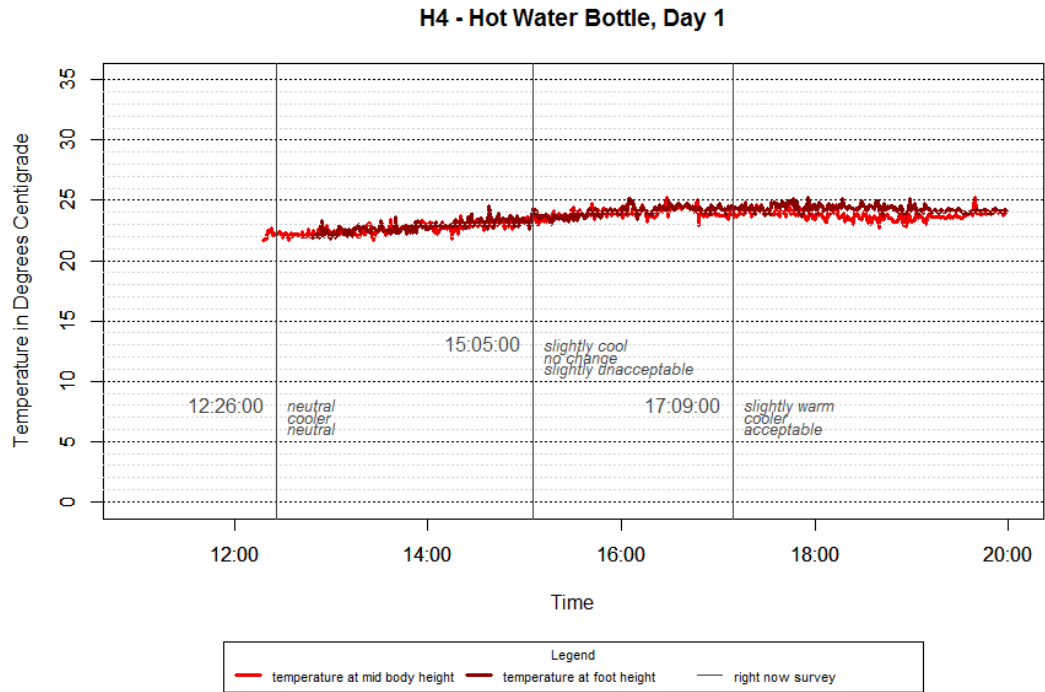
Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
14:15	Seated, 1.0 met		At room temperature	
16:30	Seated, 1.0 met		At room temperature	Went to the printing room for a few minutes;
18:30	Seated, 1.0 met		Hot	

Comments	<p>(1) "It's strange that the room thermal condition is not cold even though the weather outside is 8°C (BBC weather forecast). This comment is based on my assumption that it should be colder here because the temp outside is the same as yesterday's temp."</p> <p>(2) "The temperature in this room is perfect for long-hour working in. It would be nice if the central heating can produce heat up the room temperature right now."</p>
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Participant H4

Hot Water Bottle

H4 – Hot Water Bottle, DAY 1



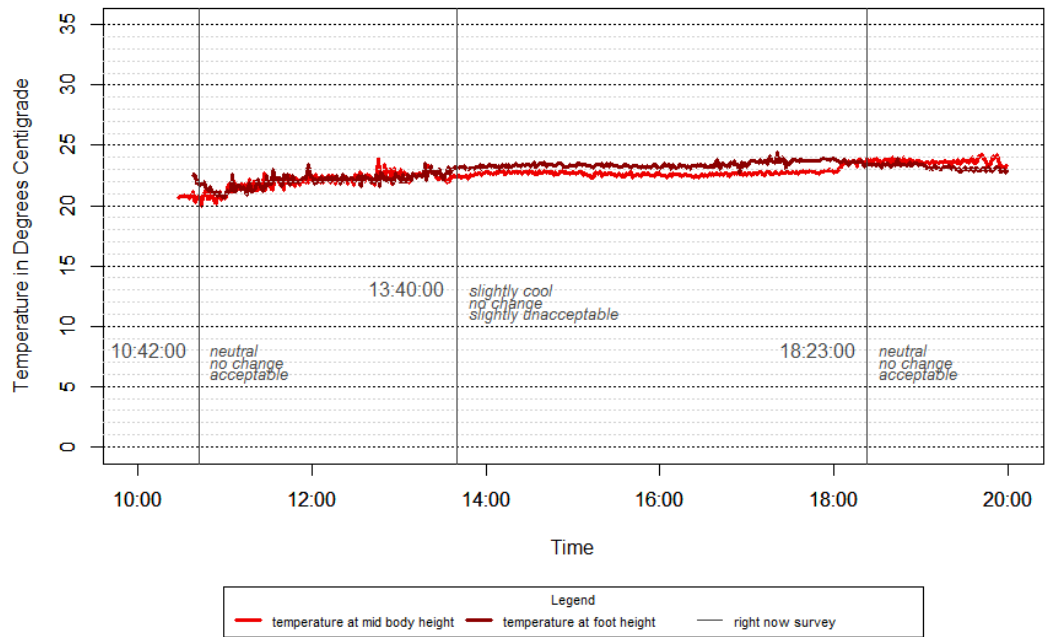
Outdoor Weather	Cloudy/Grey to partly cloudy to clear/sunny
Clothing	Medium-weight tights, socks, sweater, scarf, heavy-weight dress;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:26	Seated, 1.0 met		At room temperature	Removed sweater
15:05	Seated, 1.0 met	Air movement too high	hot	Added sweater
17:09	Seated, 1.0 met	Air movement too high	At room temperature	

Comment	(2) “personal cooling fans of co-workers are on” (3) “incoming sun heated up a bit”, “fan from co-worker is still slightly uncomfortable”
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H4 – Hot Water Bottle, DAY 2

H4 - Hot Water Bottle, Day 2



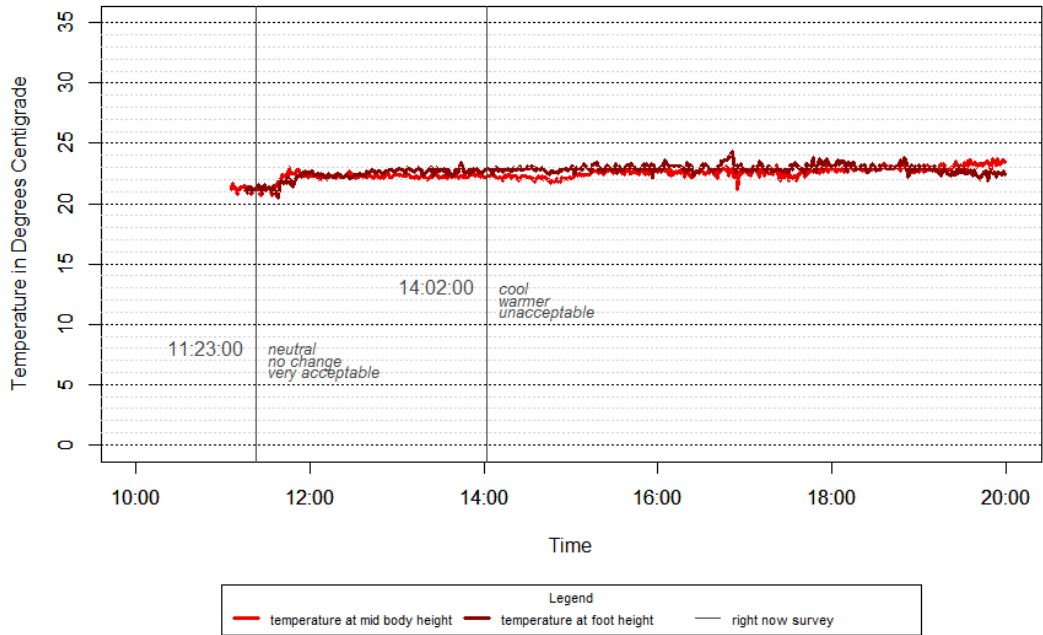
Outdoor Weather	
Clothing	Light-weight base layer and scarf, medium-weight trousers, dress, socks, sweater;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:42	Seated, 1.0 met			Removed scarf
13:40	Seated, 1.0 met	Air movement too high		
18:23	Seated, 1.0 met		Cold	

Comments	(2) "Ventilator air draft is too cooling (fan of co-worker)"
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H4 – Hot Water Bottle, DAY 3

H4 - Hot Water Bottle, Day 3



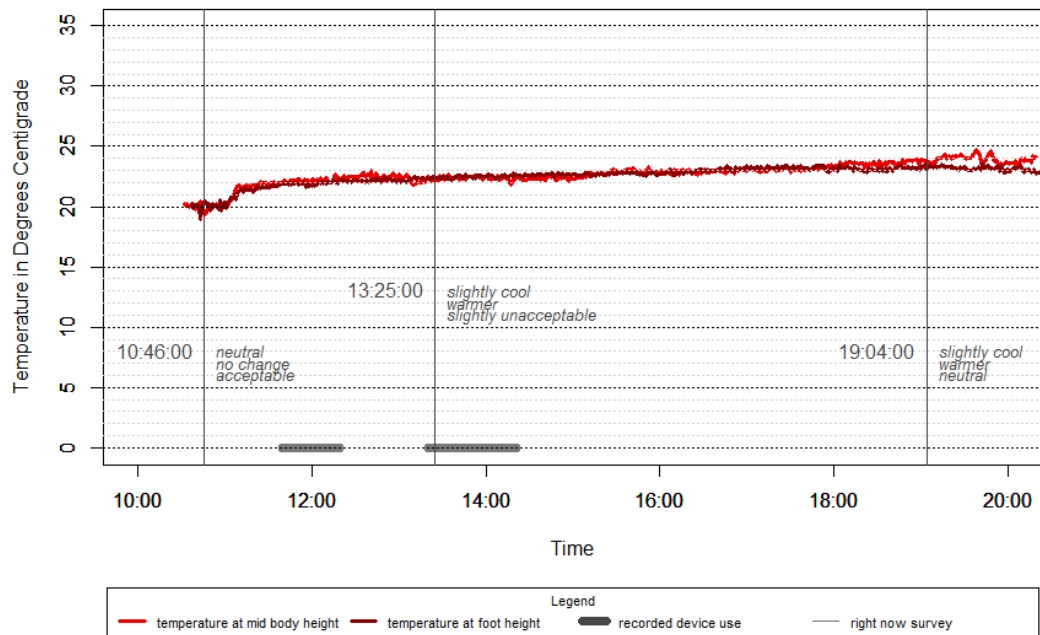
Outdoor Weather	Partly cloudy to cloudy/grey and drizzly
Clothing	Light-weight base layer, medium-weight trousers, dress, socks, sweater;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:23	Seated, 1.0 met			
14:02	Seated, 1.0 met	Air movement too high, drafts from windows	cold	Added light scarf

Comments	(2) "I did not use the bottle because I was too lazy to get up and fill it with hot water. I thought it might not be to helpful against the cold air movement bothering me."
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H4 – Heated Gloves, DAY 1

H4 - Heated Gloves, Day 1



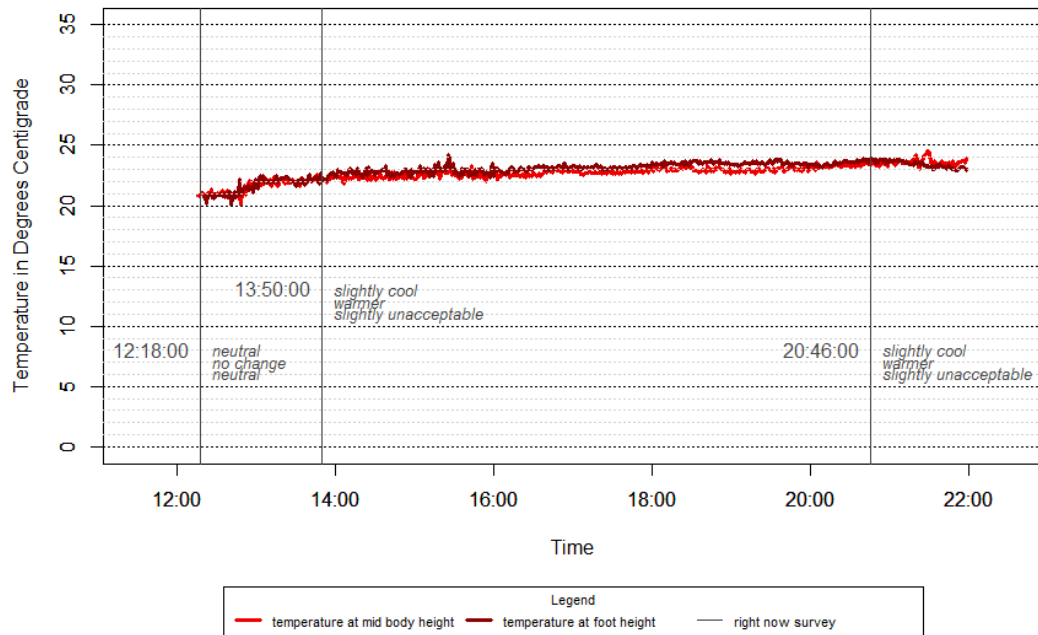
Outdoor Weather	Partly cloudy to cloudy/grey to partly cloudy
Clothing	Light-weight base layer and scarf, medium-weight long-sleeved top, trousers, socks, sweater;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:46	Seated, 1.0 met		Hot	Removed sweater and scarf
13:25	Seated, 1.0 met	Heating system provides not enough heat, personal heating device provides not enough heat;	cold	Used the gloves, added sweater
19:04	Seated, 1.0 met			

Comments	(2) "Device just provides heat for hands not for core body"
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H4 – Heated Gloves, DAY 2

H4 - Heated Gloves, Day 2

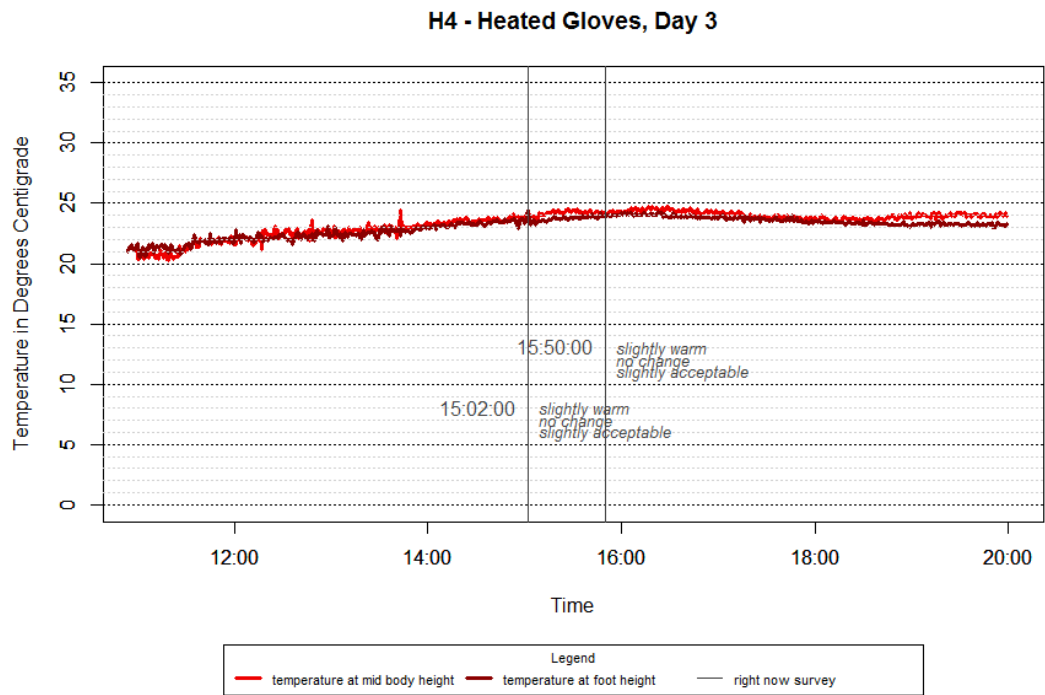


Outdoor Weather	Clear/sunny and stormy to partly cloudy and stormy
Clothing	Light-weight base layer and scarf, medium-weight long-sleeved top, trousers, socks, sweater;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:18	Seated, 1.0 met	Air movement too high, drafts from windows, windows let in the wind	Cold and warm	Removed scarf and sweater
13:50	Seated, 1.0 met	Drafts from windows	cold	Added sweater
20:46	Seated, 1.0 met	Drafts from windows, heating system provides not enough heat		Removed sweater

Comments	(3) “cold hands”
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H4 – Heated Gloves, DAY 3



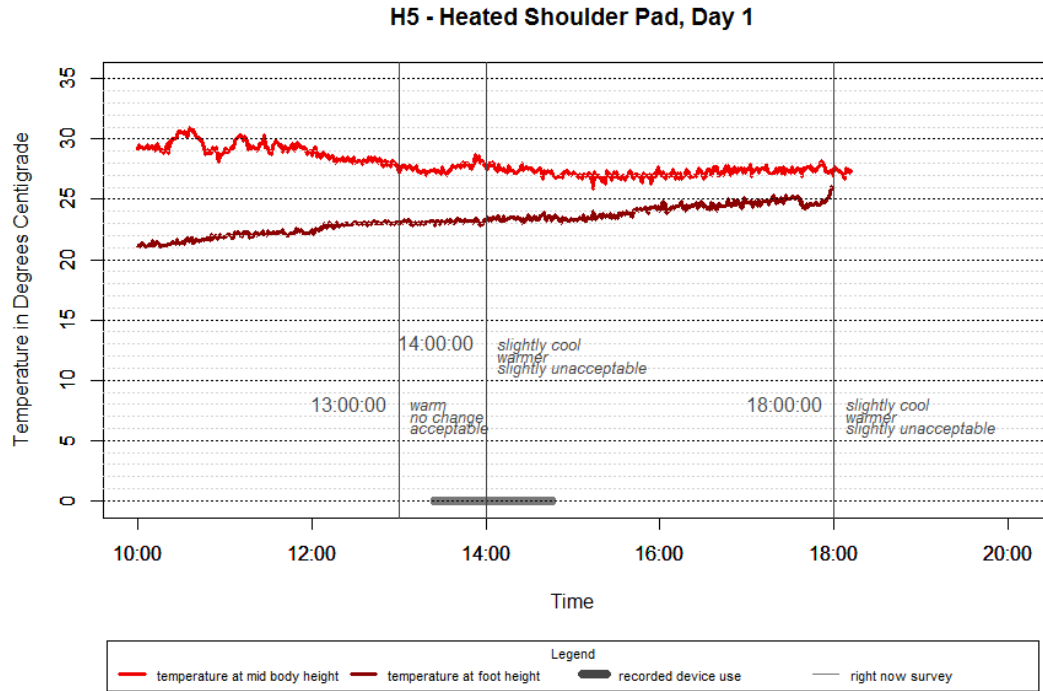
Outdoor Weather	Clear/sunny
Clothing	Light-weight base layer and scarf, medium-weight trousers, dress, socks, sweater;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
15:02	Seated, 1.0 met, High activity, walking, 2.0 met (5 minutes before)		hot	Removed scarf
15:50	Seated, 1.0 met		cold	Added sweater

Participant H5

Heated Shoulder Pad

H5 – Heated Shoulder Pad, DAY 1



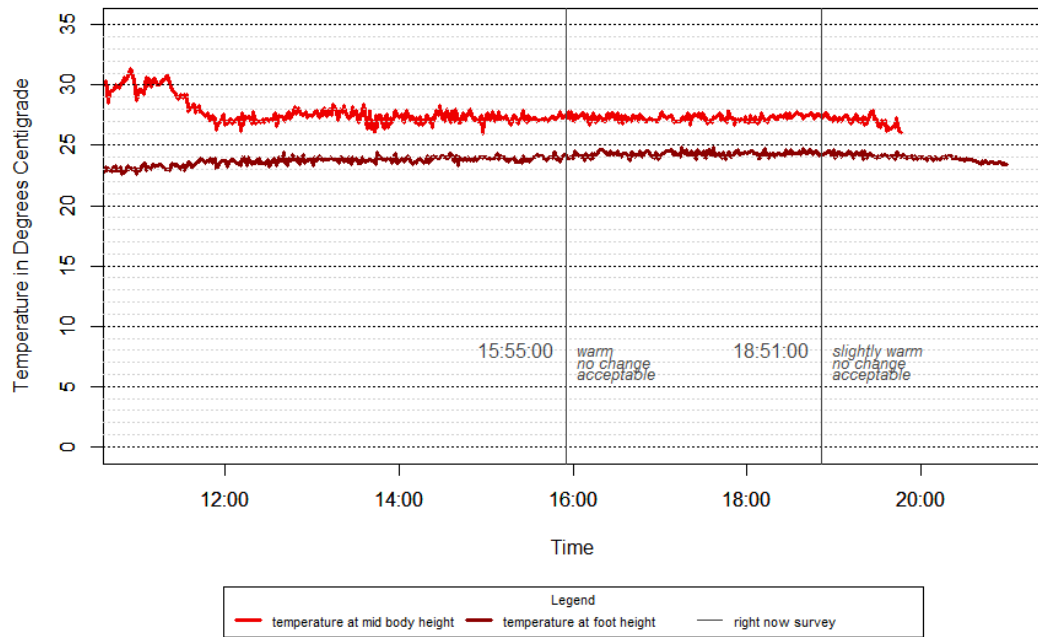
Outdoor Weather	Clear/sunny to partly cloudy to cloudy/grey
Clothing	Light-weight base layer, long-sleeved shirt, socks, medium-weight sweater

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
13:00	Seated, 1.0 met		cold	
14:00	Seated, 1.0 met	Heating system provides not enough heat	cold	Used the device
18:00	Seated, 1.0 met		Cold and hot	

Comments	(3) "My feet are cold"
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H5 – Heated Shoulder Pad, DAY 2

H5 - Heated Shoulder Pad, Day 2

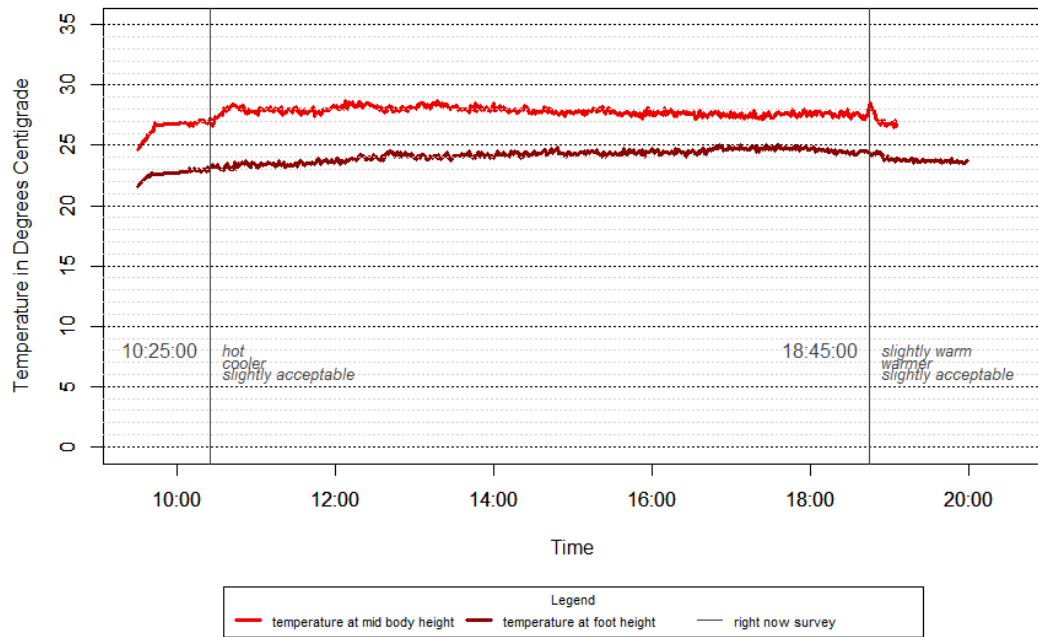


Outdoor Weather	Clear/sunny
Clothing	Light-weight base layer, long-sleeved shirt, socks, jacket, sweater

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
15:55	Light activity, standing, 1.4 met		hot	Removed jacket
18:51	Seated, 1.0 met			

H5 – Heated Shoulder Pad, DAY 3

H5 - Heated Shoulder Pad, Day 3



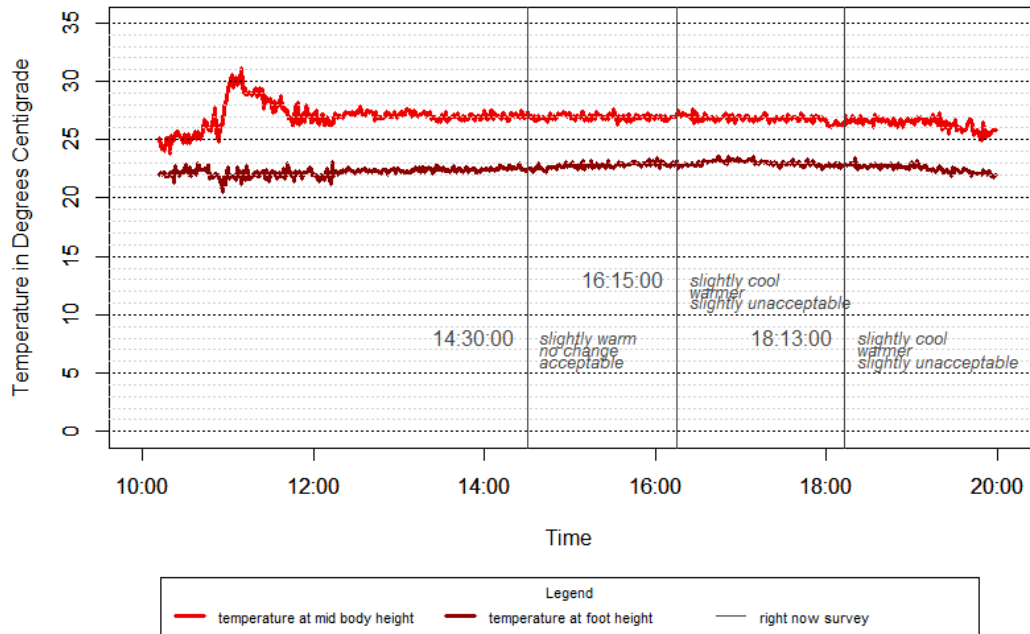
Outdoor Weather	Clear/sunny to partly cloudy
Clothing	Light-weight base layer, long-sleeved shirt, socks, jacket

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:25	High activity, walking, 2.0 met	Incoming sun	hot	Removed jacket
18:45	Seated, 1.0 met		water	

Personal Fan Heater

H5 – Personal Fan Heater, DAY 1

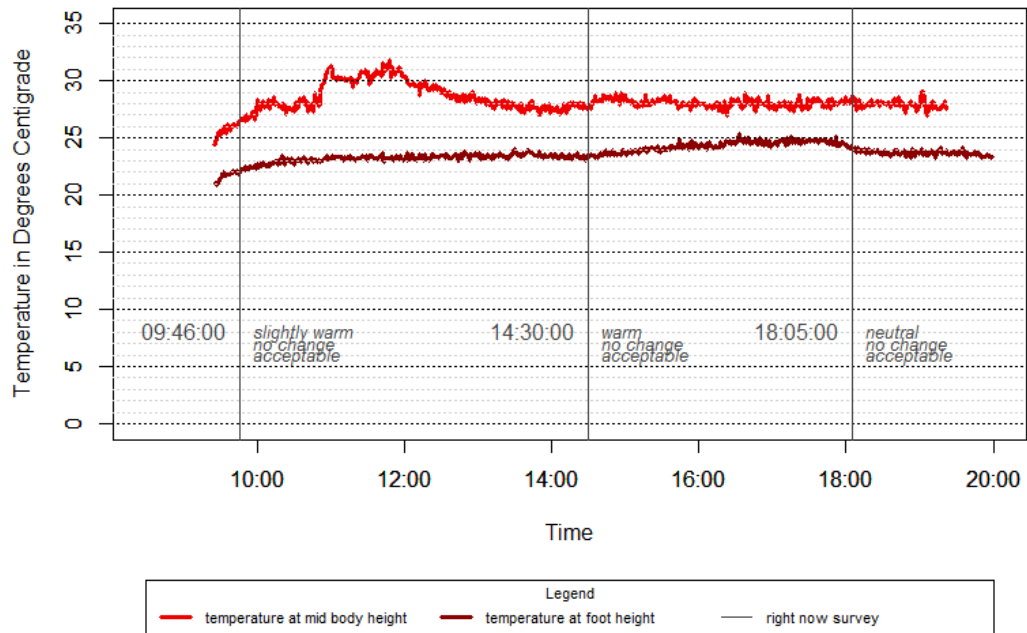
H5 - Personal Fan Heater, Day 1



Outdoor Weather	Partly cloudy to cloudy/grey
Clothing	Light-weight base layer, long-sleeved shirt, socks, jacket, hat/cap

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
14:30	Seated, 1.0 met		lunch	Removed jacket, hat
16:15	Seated, 1.0 met	Heating system provides not enough heat, personal heating device provides too much heat	cold	Used the fan heater
18:13	Seated, 1.0 met	Heating system provides not enough heat, "my feet are cold"		

H5 - Personal Fan Heater, Day 2

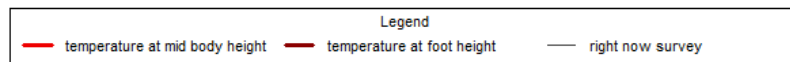
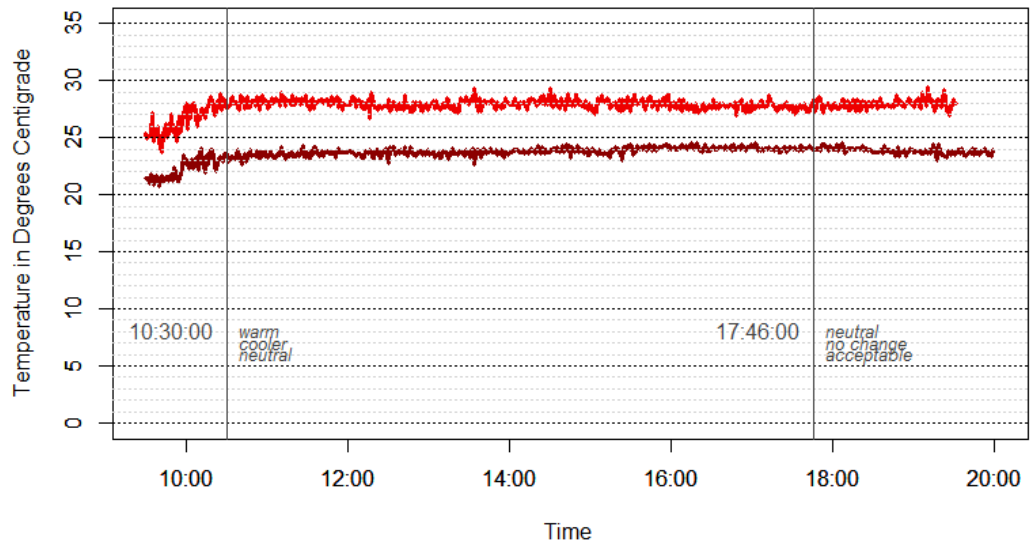


Outdoor Weather	Clear/sunny to partly cloudy
Clothing	Light-weight base layer, short-sleeved shirt, socks, jacket

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:46	High activity, walking, 2.0 met		cold	Removed jacket
14:30	Light activity, standing, 1.4 met		hot	
18:05	Seated, 1.0 met			

Comment	(3) "It was a good sunny day."
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H5 - Personal Fan Heater, Day 3



Outdoor Weather	Partly cloudy to cloudy/grey
Clothing	Light-weight base layer, short-sleeved shirt, jacket

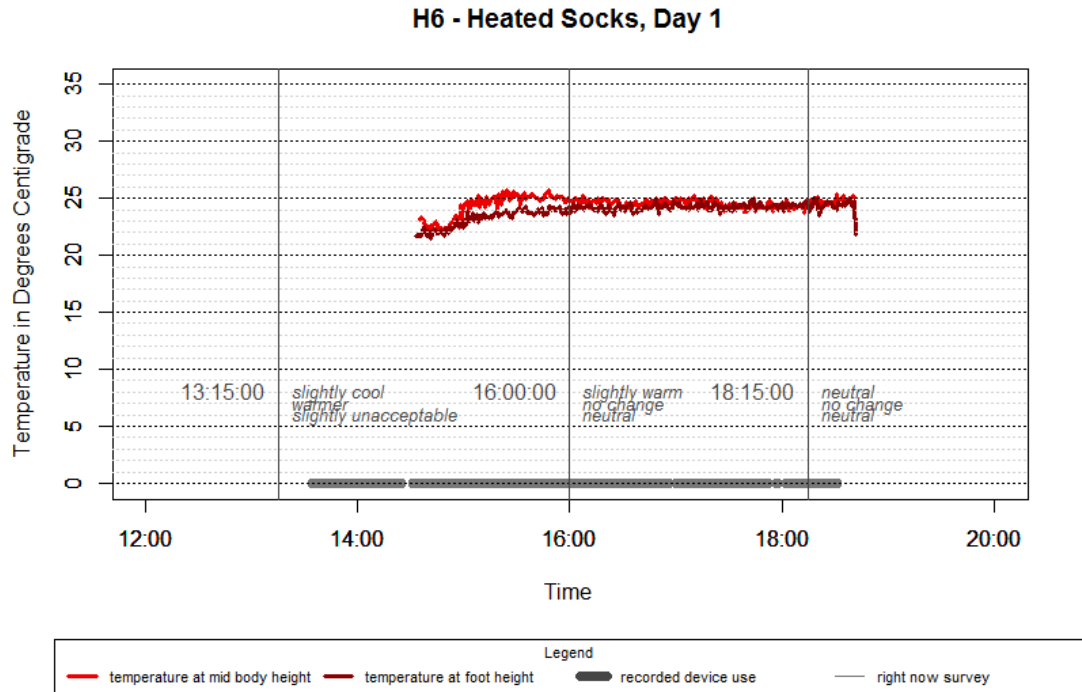
Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:30	High activity, walking, 2.0 met		cold	Removed jacket
17:46	Seated, 1.0 met		hot	

Comments	(1) "I was sweating, I was walking fast."
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Participant H6

Heated Socks

H6 – Heated Socks, DAY 1

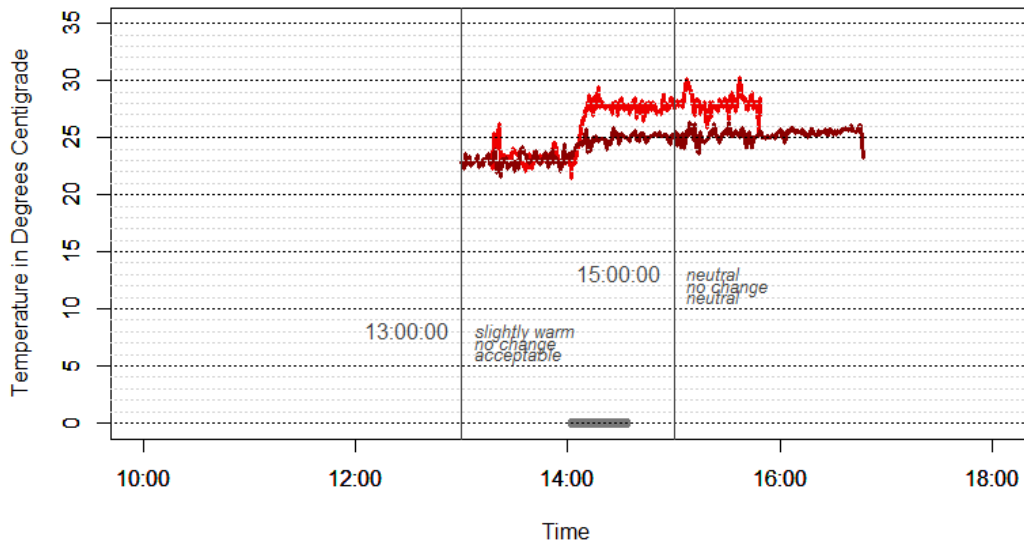


Outdoor Weather	Clear/sunny
Clothing	Medium-weight short-sleeved top, trousers, socks, jacket, hat/cap;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
13:15	Standing, relaxed, 1.2 met	Heating system provides not enough heat (radiator)	warm	Removed jacket
16:00	Seated, 1.0 met			Used the socks (device shorted), removed hat
18:15	Seated, 1.0 met			Used the socks

Comments	(2) “Wearing shoes – a little overwhelming but generally warmer.” (3) “Let the batteries run down – realised turn on and off – oh! Then better.”
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H6 - Heated Socks, Day 2

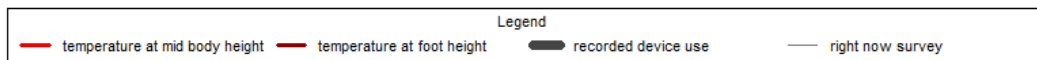
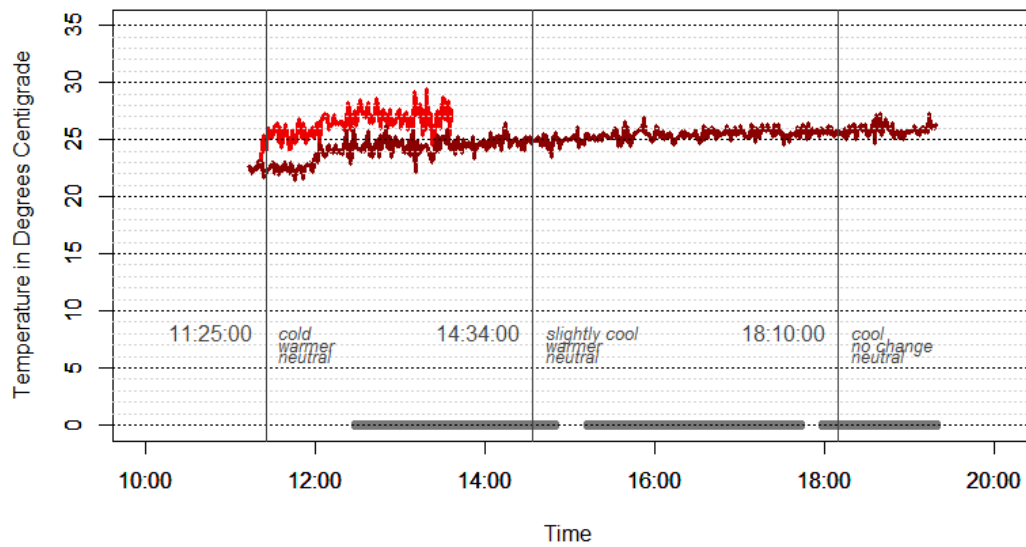


Legend			
—	temperature at mid body height	—	temperature at foot height
	recorded device use		right now survey

Outdoor Weather	Clear/sunny
Clothing	Medium-weight base-layer, long-sleeved top, trousers, jacket, heavy-weight socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
13:00	Light activity, standing, 1.4 met		hot	Removed hat, gloves, 2 jacket
15:00	Seated, 1.0 met			

H6 - Heated Socks, Day 3



Outdoor Weather	Partly cloudy to clear/sunny
Clothing	Light-weight long-sleeved top, Medium-weight base-layer, trousers, heavy-weight socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:45	High activity, walking, 2.0 met		hot	Removed heavy jacket; switched shoes and socks out for heated
14:34	Light activity, standing, 1.4 met		Warm and room temperature	Used the socks
18:10	Seated, 1.0 met			

Comments	(2) "Forgot to turn on transmitter & hot burned at one point (short) periodically used warmers" (3) "Haven't used recently but have periodically"
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B.5 Environmental Data and Right Now Survey Plots

Answers to the following questions are depicted in the graphs:

1.	How do you feel right now?						
	○	○	○	○ ⋮ ○	○	○	○
	Cold	Cool	Slightly Cool	Neutral	Slightly Warm	Warm	Hot
2.	Would you like to be						
	<input type="checkbox"/>	Cooler					
	<input type="checkbox"/>	No change					
	<input type="checkbox"/>	Warmer					
3.	How acceptable is the temperature to you?						
	○	○	○	○ ⋮ ○	○	○	○
	Very Unacceptable	Unacceptable	Slightly Unacceptable	Neutral	Slightly Acceptable	Acceptable	Very Acceptable

Participant C1

Wrist Coolers

C1 – Wrist Coolers, DAY 1

No sensor data was recorded

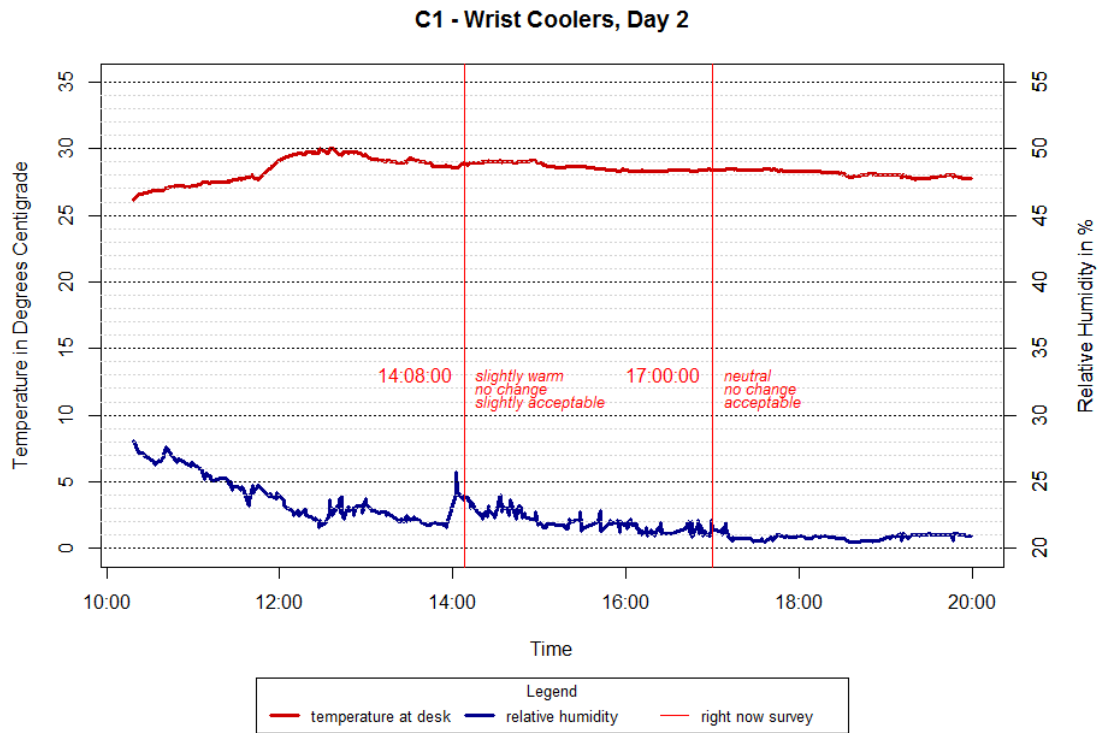
17:00 Slightly warm – Cooler - Slightly acceptable

18:15 Neutral – No change – Neutral

Outdoor Weather	Partly cloudy
Clothing	lightweight base layer, short sleeved shirt and trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
17:00	Seated, 1.0 met	Air movement, hot surrounding surfaces		Used the wrist coolers
18:15	Seated, 1.0 met		At room temperature	

C1 – Wrist Coolers, DAY 2

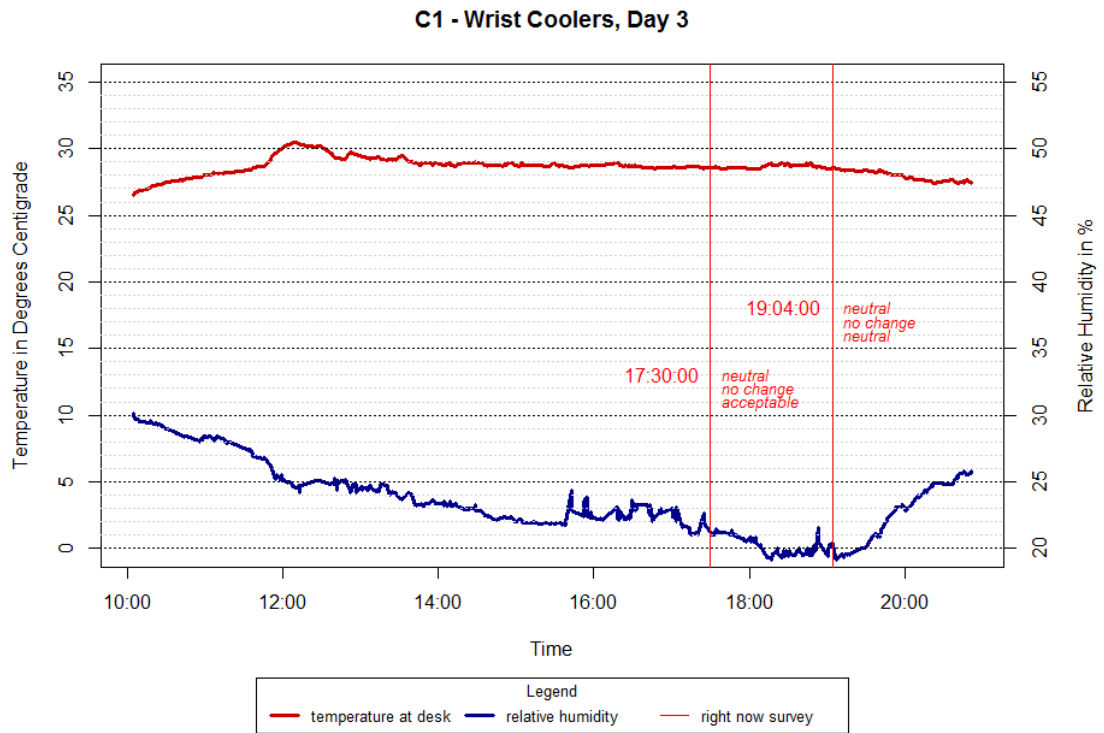


Outdoor Weather	clear/sunny
Clothing	lightweight base layer, short sleeved shirt and trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
14:08	High activity, walking, 2.0 met		Hot	
17:00	Seated, 1.0 met		At room temperature	Used the wrist coolers

Comments	(2) "I removed the cold pack and put them around my neck."
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C1 – Wrist Coolers, DAY 3

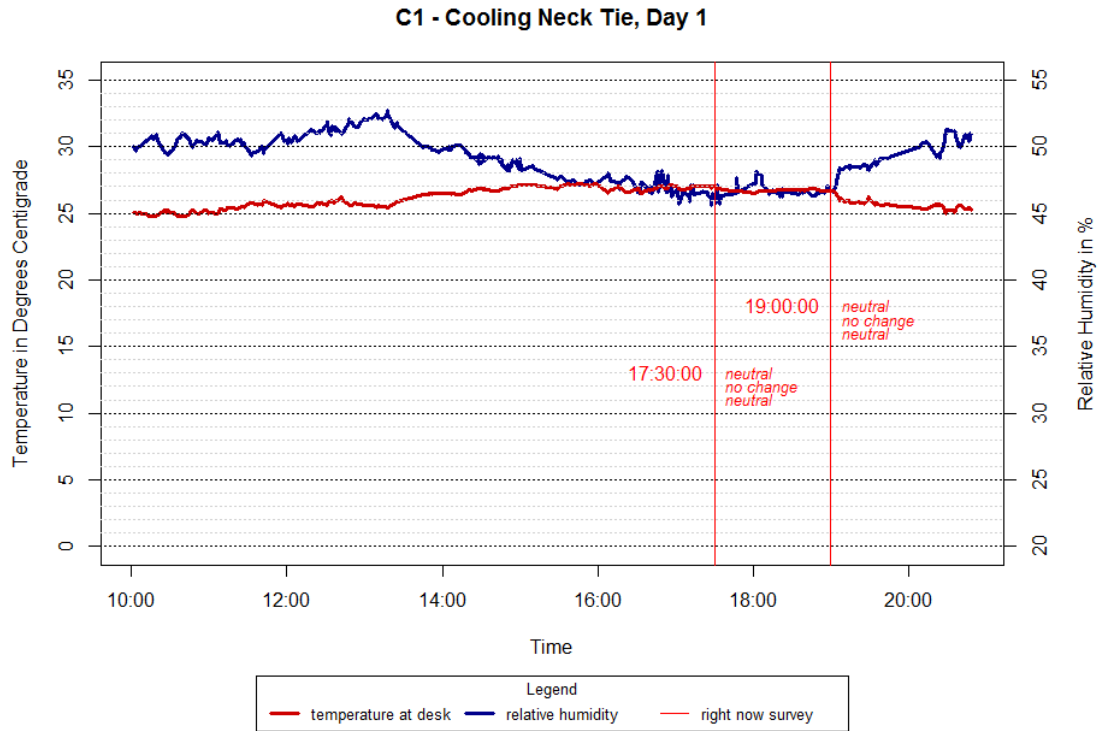


Outdoor Weather	clear/sunny
Clothing	lightweight base layer, short sleeved shirt and shorts, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
17:30	Seated, 1.0 met		at room temperature	
19:04	Seated, 1.0 met		at room temperature	

1) Cooling Neck Tie

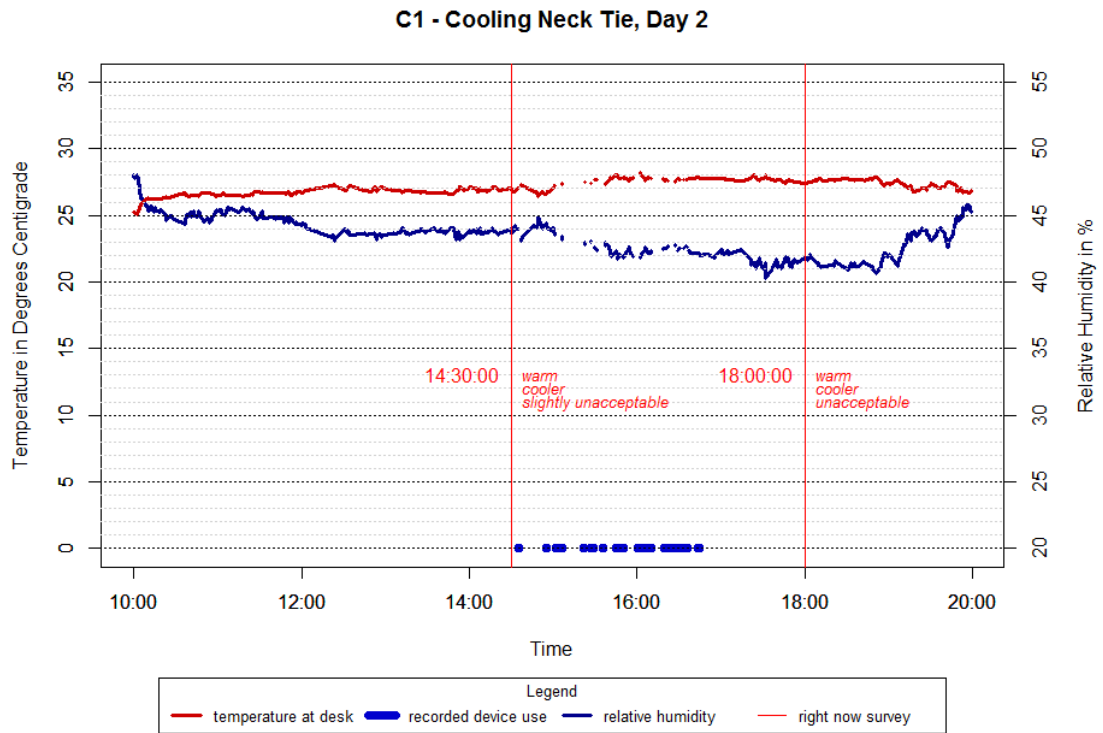
C1 – Cooling Neck Tie, DAY 1



Outdoor Weather	cloudy/grey
Clothing	lightweight base layer, short sleeved shirt and trousers, socks; jacket

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
17:30	Seated, 1.0 met		at room temperature	Removed jacket
19:00	Seated, 1.0 met		at room temperature	

C1 – Cooling Neck Tie, DAY 2

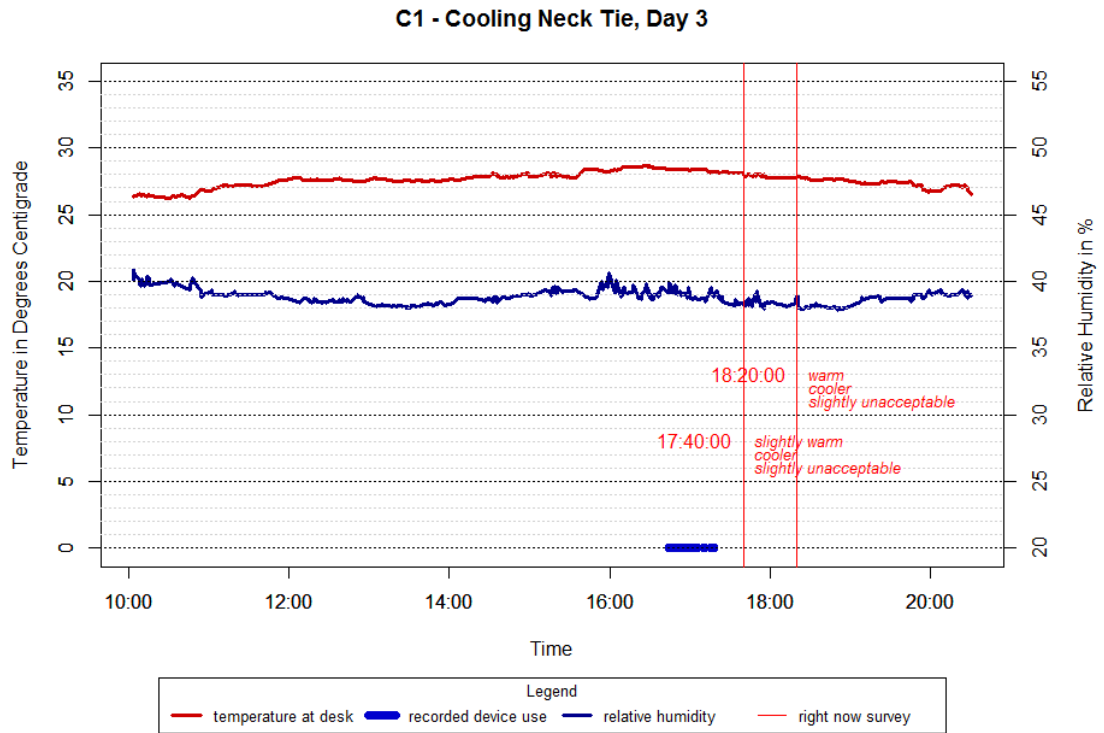


Outdoor Weather	cloudy/grey
Clothing	lightweight base layer, short sleeved shirt and trousers, socks; sweater

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
14:30	Seated, 1.0 met	Cooling system provides not enough cooling	at room temperature	Removed jacket; used cooling neck tie
18:00	Seated, 1.0 met	Hot surrounding surfaces	at room temperature	used cooling neck tie

Comments	(1) "It is too hot."
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C1 – Cooling Neck Tie, DAY 3

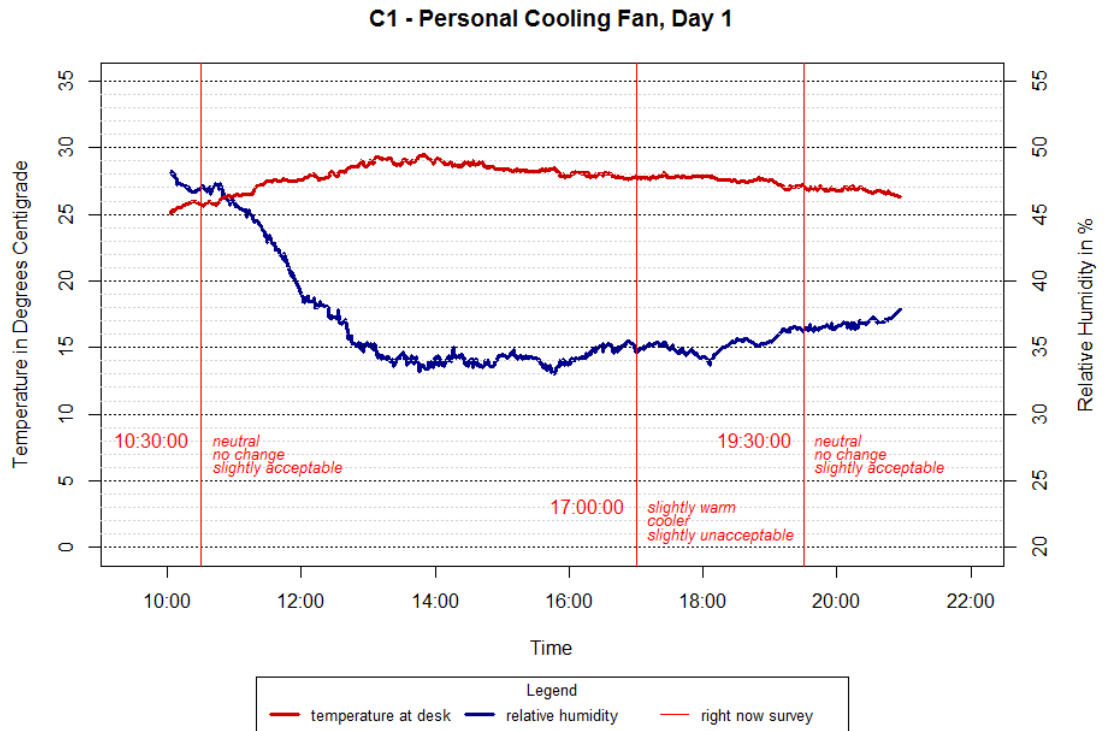


Outdoor Weather	Partly cloudy
Clothing	lightweight base layer, short sleeved shirt and trousers, socks; sweater

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
17:40	Seated, 1.0 met	Hot surrounding surfaces		Removed jacket; used cooling neck tie
18:20	High activity, walking, 2.0 met	Hot surrounding surfaces		

Personal Cooling Fan

C1 – Personal Cooling Fan, DAY 1

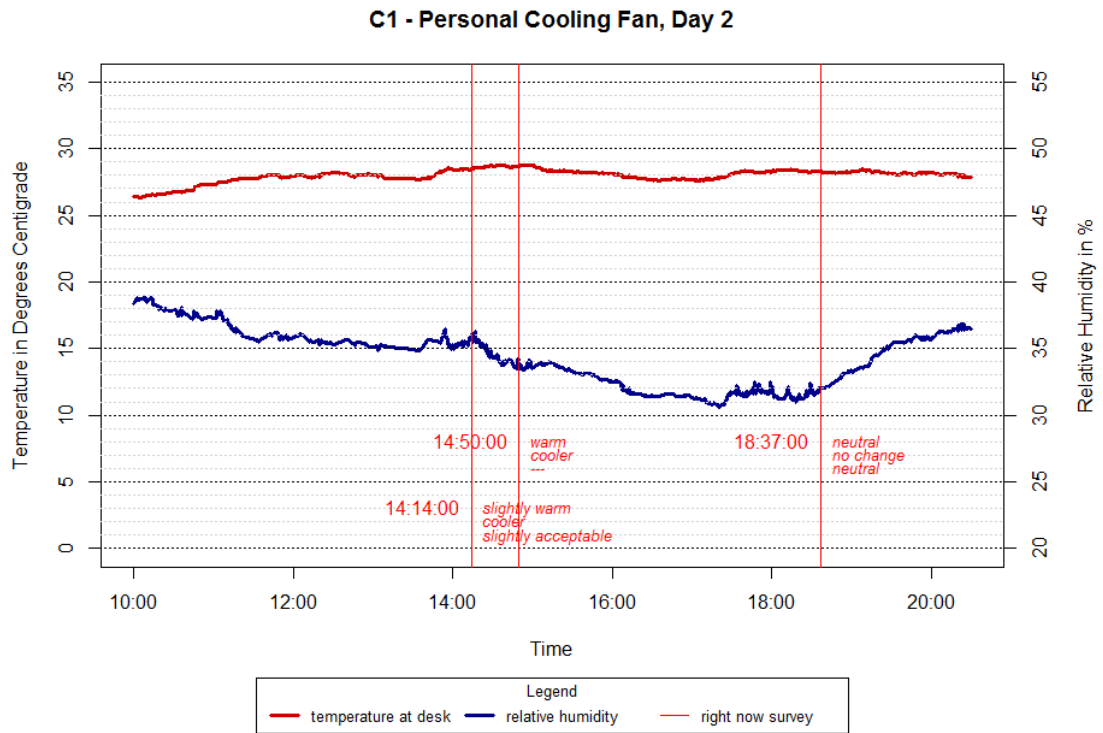


Outdoor Weather	Cloudy/Grey to partly cloudy
Clothing	lightweight base layer, short sleeved shirt and trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:30	Seated, 1.0 met		Hot	
17:00	Seated, 1.0 met	Hot surrounding surfaces		Used the cooling fan
19:30	Seated, 1.0 met			

Comments	(2) “The fan could be too noisy and disturb colleagues.”
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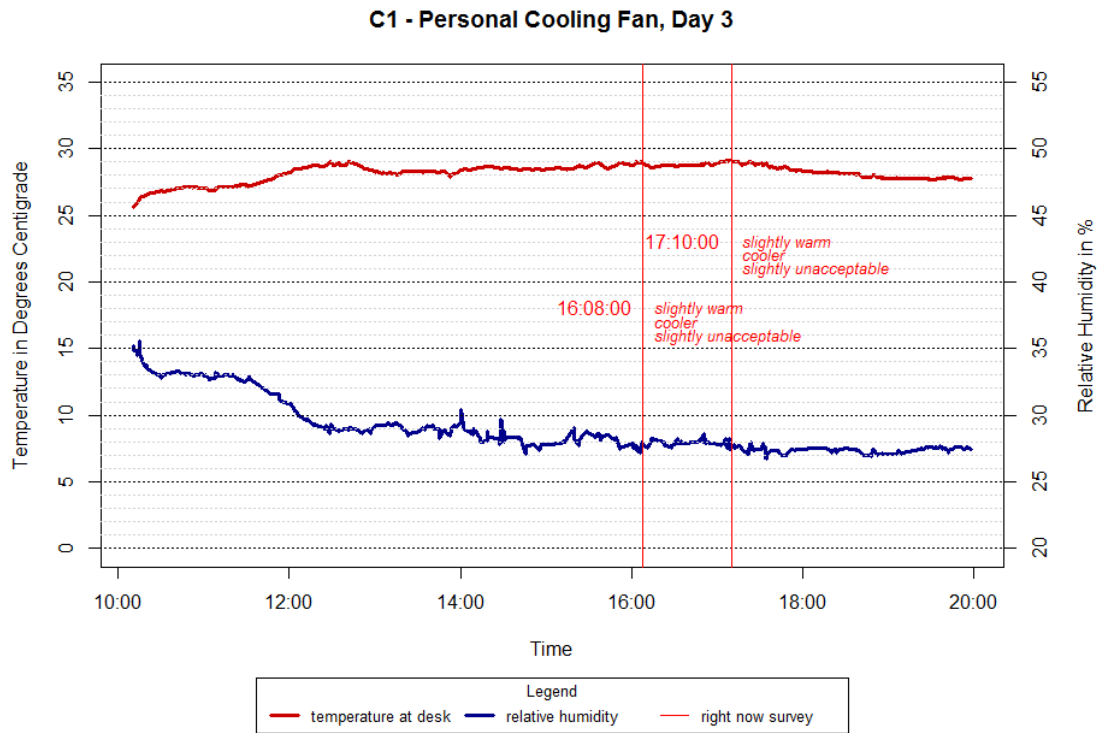
C1 – Personal Cooling Fan, DAY 2



Outdoor Weather	Partly cloudy to sunny
Clothing	lightweight base layer, long sleeved shirt and trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
14:14	Seated, 1.0 met	Hot surrounding surfaces	Hot	
14:50	Seated, 1.0 met	Hot surrounding surfaces	at room temperature	Used the cooling fan
18:37	Seated, 1.0 met			Used the cooling fan

C1 – Personal Cooling Fan, DAY 3



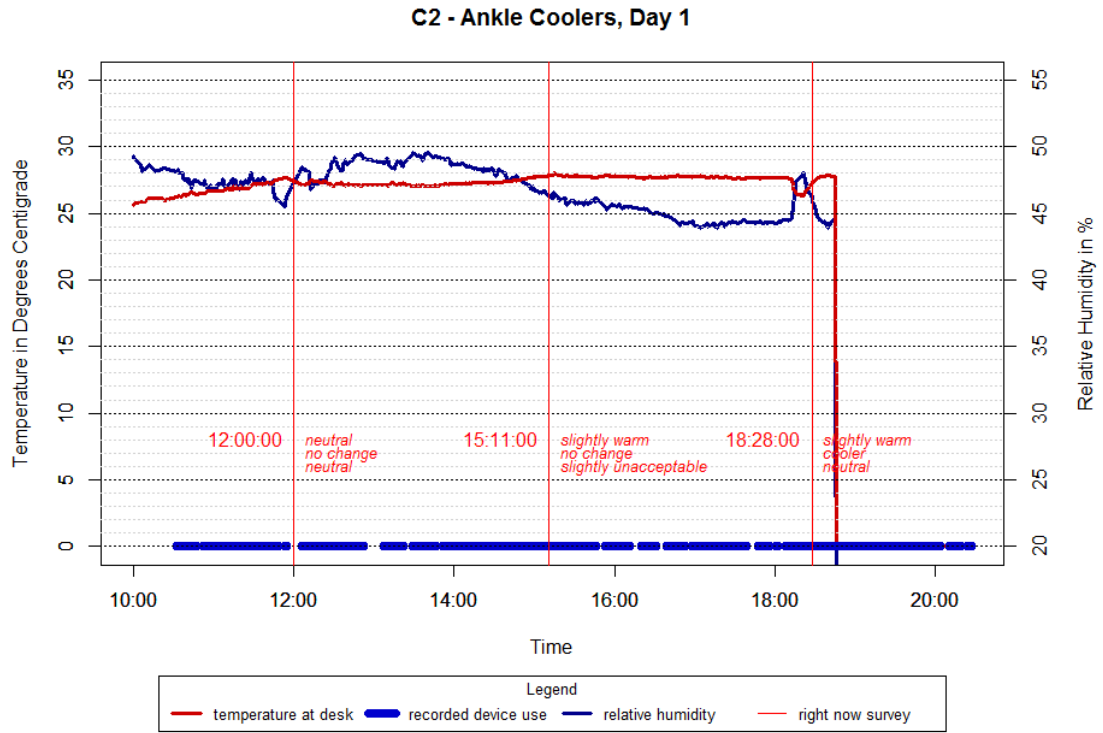
Outdoor Weather	Partly cloudy
Clothing	lightweight base layer, short sleeved shirt and trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
16:08	Seated, 1.0 met	Hot surrounding surfaces	at room temperature	Used the cooling fan
17:10	Seated, 1.0 met	Hot surrounding surfaces	at room temperature	Used the cooling fan

Participant C2

Ankle Coolers

C2 – Ankle Coolers, DAY 1

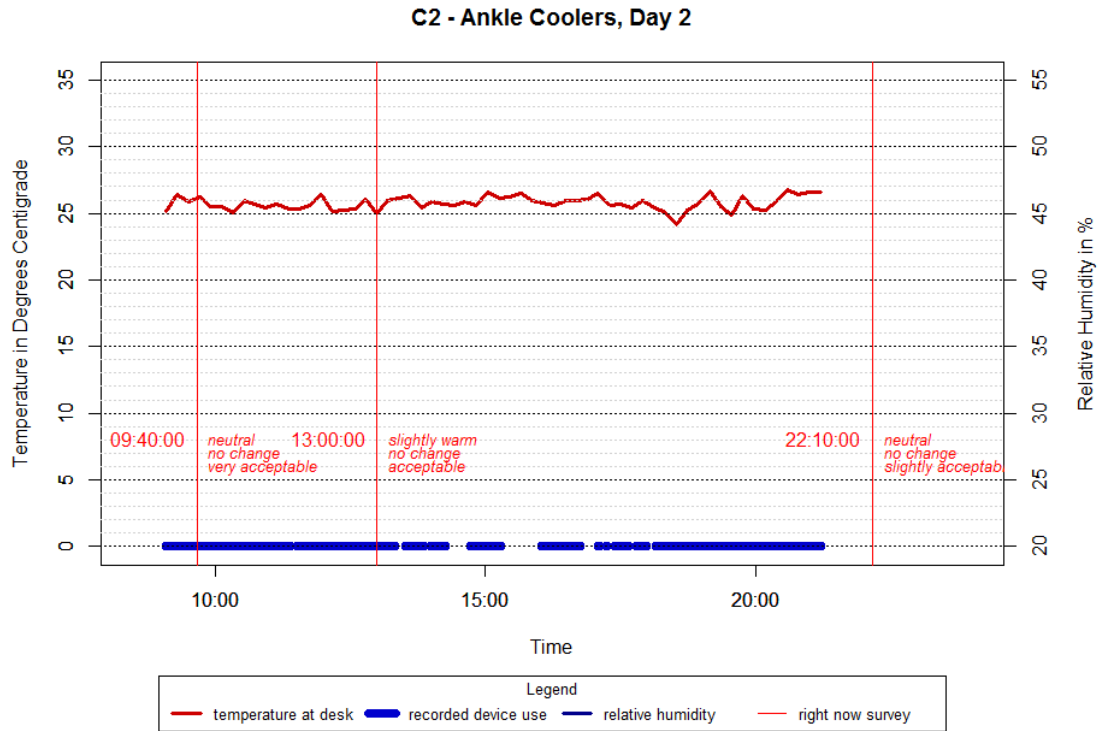


Outdoor Weather	Foggy/Misty
Clothing	Light-weight base layer, trousers, socks, and medium-weight short sleeved shirt; light-weight sweater

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:00	Seated, 1.0 met			
15:11	Seated, 1.0 met	Air movement too low, hot windows; no fresh air and air exchange		In building but not in office because office is too warm
18:28	Seated, 1.0 met	Air movement too low, hot floor, ceiling, walls; no fresh air	cold	Walking outside to enjoy a cool breeze

Comments	<p>(1) "It would be nicer to have some fresh air. Generally speaking, thermal condition is always nice in the morning."</p> <p>(2) "I think the current thermal condition is tolerable. Unless it's getting too hot, I prefer to let my own body be adjusted to the temperature."</p> <p>(3) "The thermal condition getting better. Maybe because the sun go down and I'm the only one left in office. So the temperature is dropping, I think. Quieter place also made me feel cooler."</p>
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C2 – Ankle Coolers, DAY 2

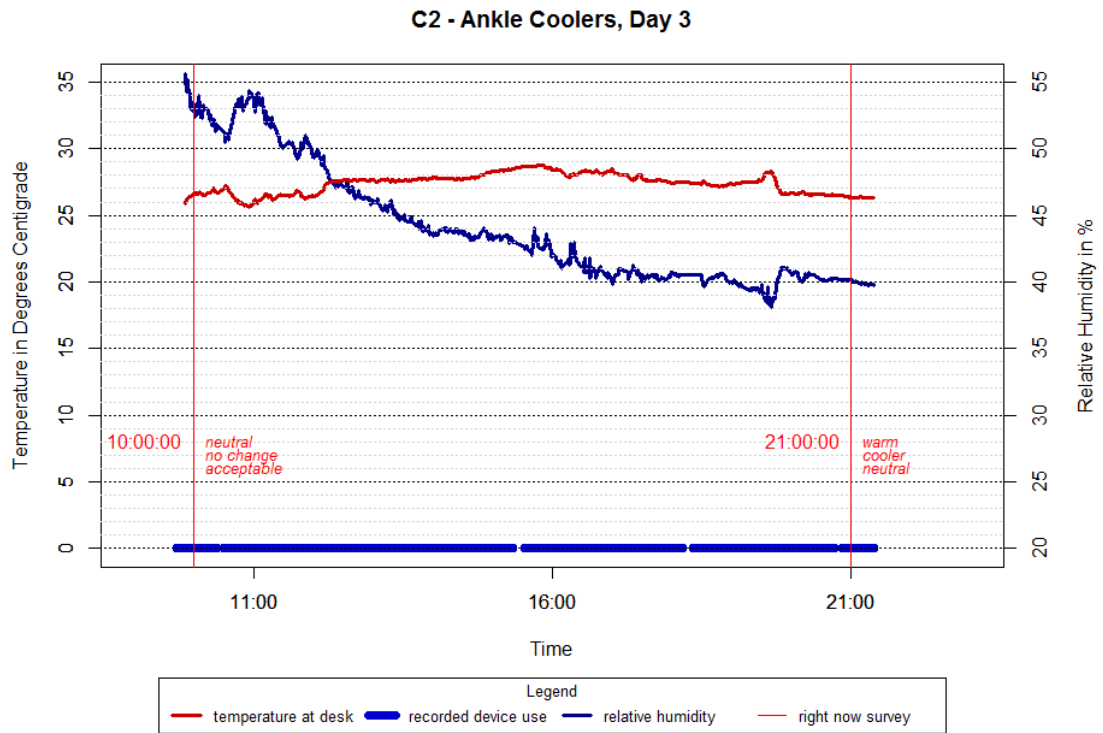


Outdoor Weather	Foggy/Misty
Clothing	lightweight base layer, short sleeved shirt and trousers, socks; sweater

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:40	Seated, 1.0 met		at room temperature	
13:00	Seated, 1.0 met	Air movement too low		In the lab before and walking back to office
22:10	Seated, 1.0 met	Air movement too low	at room temperature	

Comments	<p>(1) "The current thermal condition is good, quite comfortable."</p> <p>(2) "I hope my office could have some breeze, though the temperature is comfortable."</p> <p>(3) "I'm using the fan to speed up the air current and the current fluctuation bring some cool fresh air inside my office through the tiny gap of windows. The temperature don't change but I feel refreshed."</p>
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C2 – Ankle Coolers, DAY 3



Outdoor Weather	Clear/sunny
Clothing	lightweight base layer, sweater and trousers, socks;

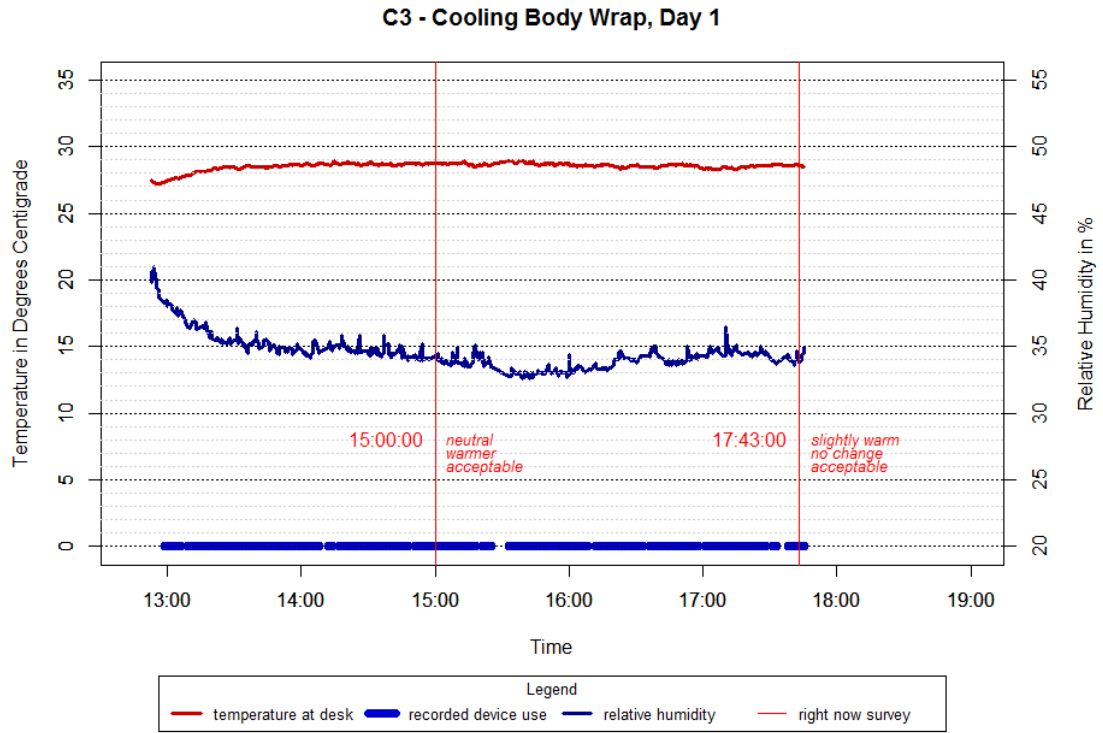
Data Points	Activity Level prior to survey	Environment	Drink	Device Use / Behavioural Adaptation
10:00	Seated, 1.0 met			
n.d.	Light activity, standing, 1.4 met	Air movement too low	at room temperature (a bit cold)	Walking on street before
21:00	Seated, 1.0 met	Air movement too low	at room temperature	Used the ankle cooler

Comments	(2) "I feel very warm. But I'm not sure if it's because the temperature in the room is high or my body temperature is high."
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Participant C3

Cooling Body Wrap

C3 – Cooling Body Wrap, DAY 1

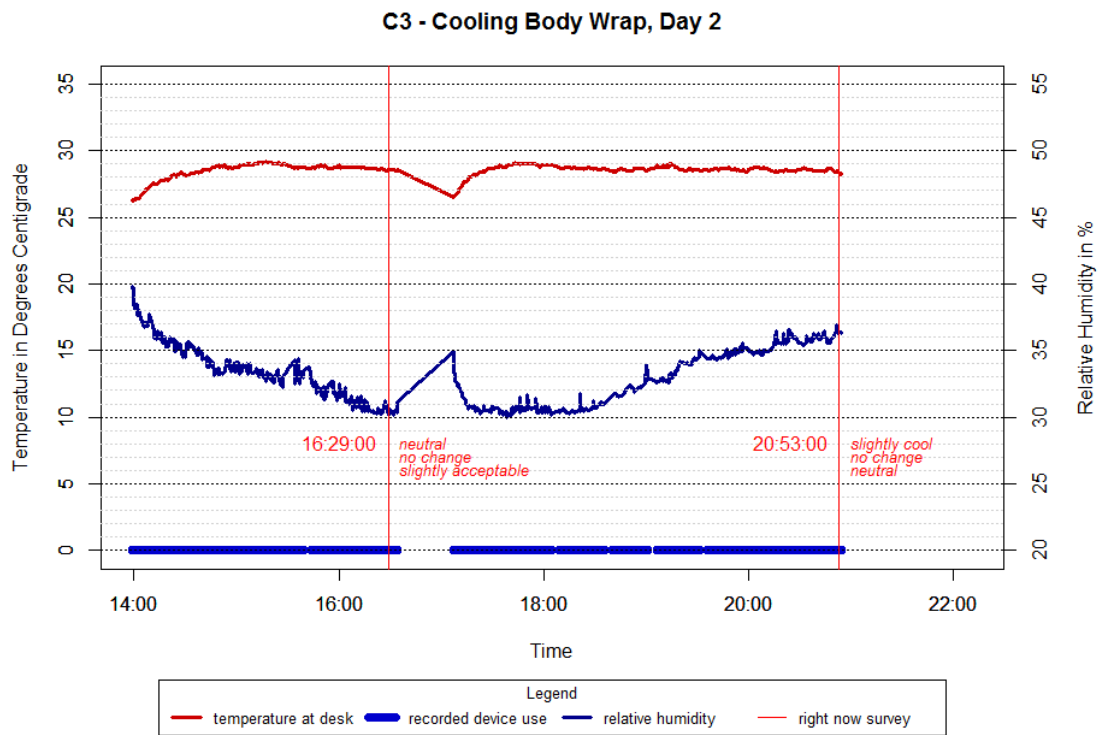


Outdoor Weather	Partly cloudy
Clothing	Medium-weight base layer, short sleeved shirt and trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
15:00	Seated, 1.0 met	Drafts from windows		Used the body wrap (provides too much cooling)
17:43	Seated, 1.0 met		Cold	

Comments	(1) “Started with personal cooling device equipped with four cooling packs; successively removed them as I felt it was too cold.”
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C3 – Cooling Body Wrap, DAY 2

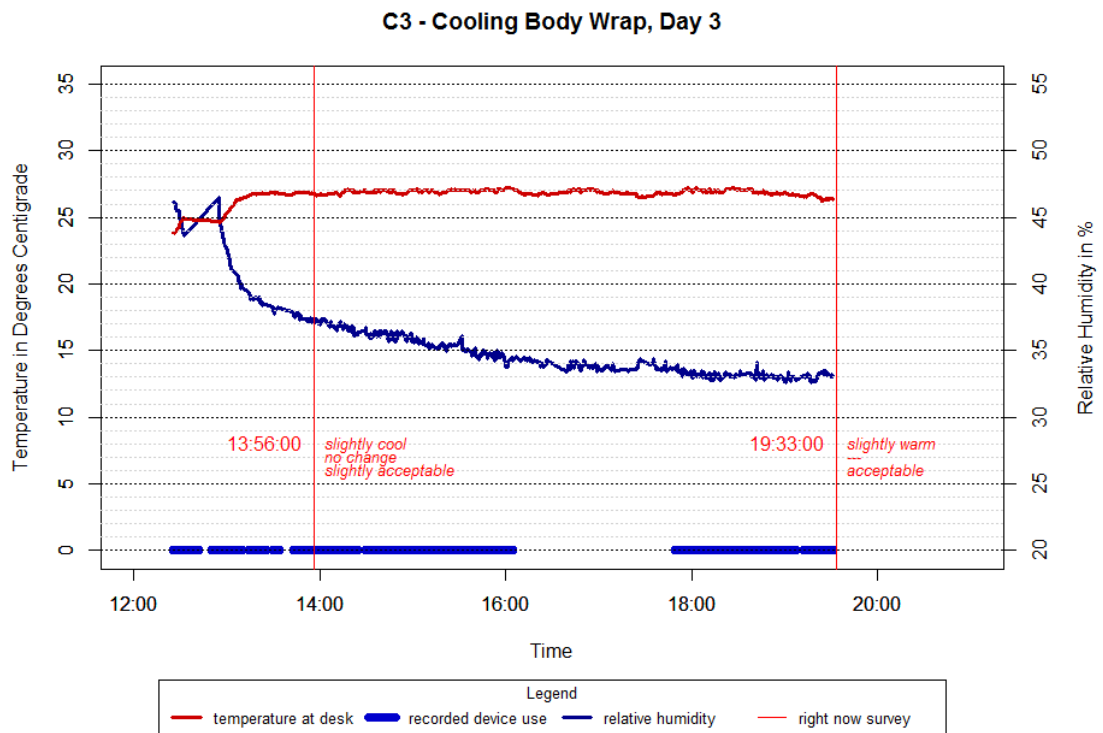


Outdoor Weather	Clear/sunny
Clothing	Medium-weight base layer, long sleeved shirt and trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
16:29	Seated, 1.0 met	Drafts from window	Cold	Used the body wrap (provides too much cooling)
20:53	Seated, 1.0 met	Not enough heating		

Comments	(1) “Slightly drafty, as the windows are open for cooling.”
----------	---

C3 –Cooling Body Wrap, DAY 3



Outdoor Weather	Partly cloudy
Clothing	Medium-weight base layer, long sleeved shirt and trousers, socks;

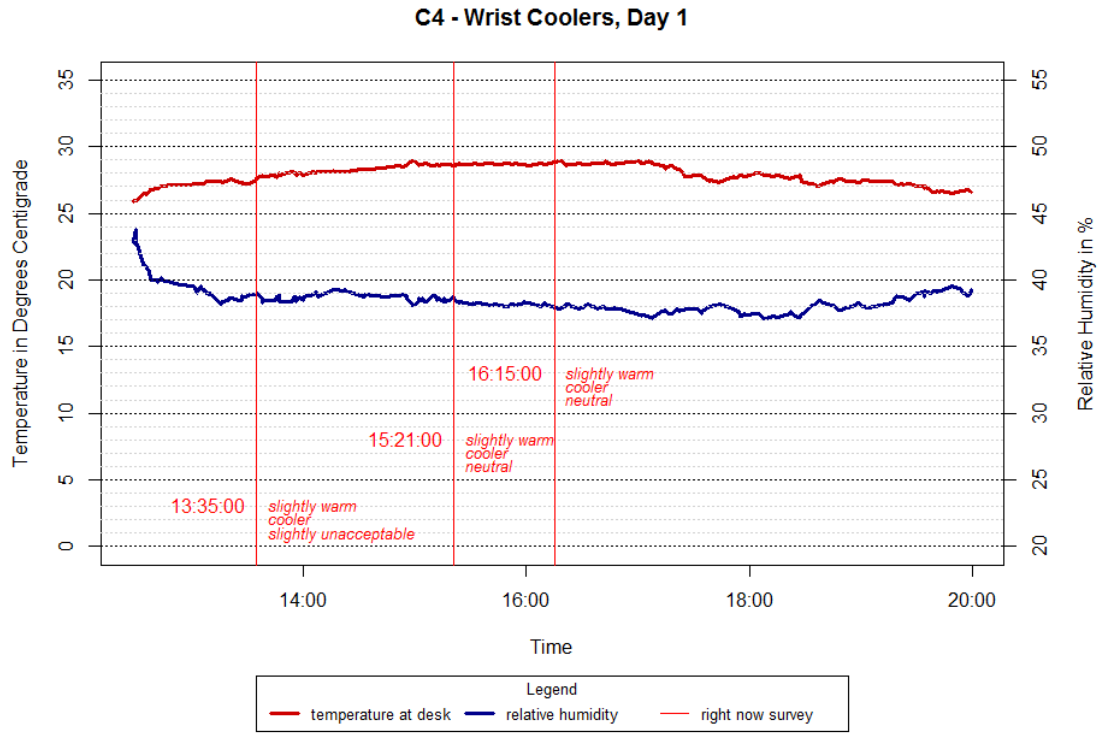
Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
13:56	Seated, 1.0 met	Drafts from windows	at room temperature	Used the body wrap
19:33	Seated, 1.0 met		at room temperature	

Comments	(1) “The cooling device is most comfortable for me when used with one cooling pack located around my belt. Used this way, my clothing provides additional insulation – otherwise I have found the cooling effect uncomfortably strong.”
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Participant C4

Wrist Coolers

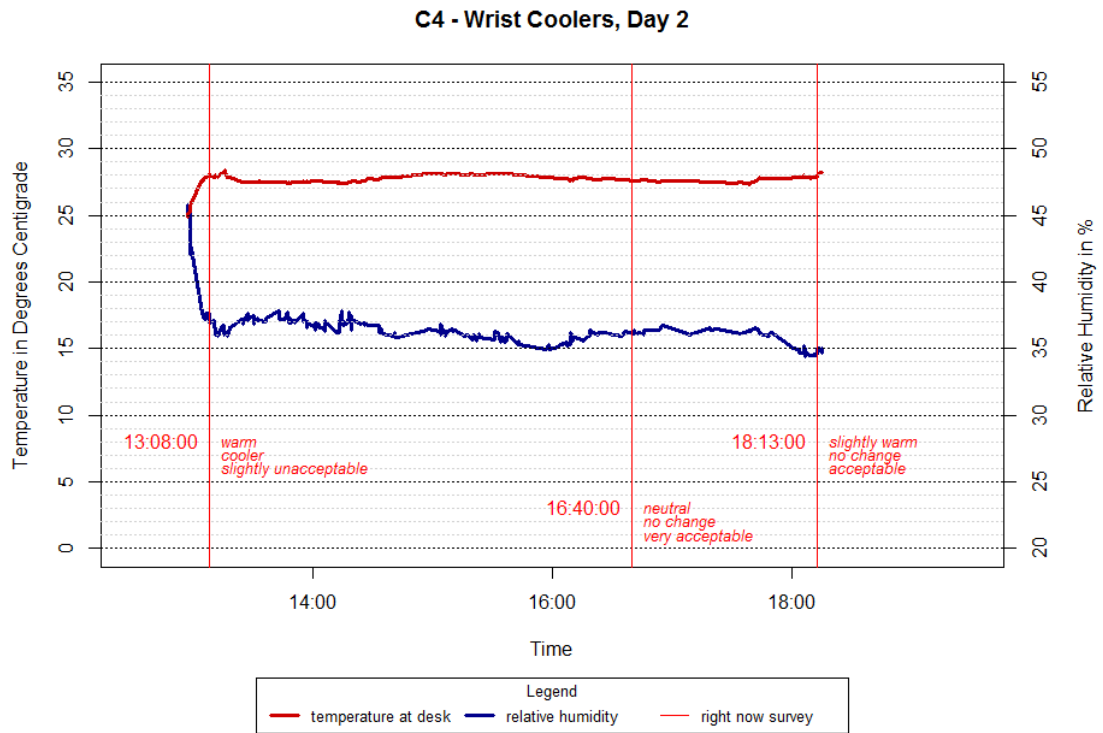
C4 – Wrist Coolers, DAY 1



Outdoor Weather	Cloudy/grey with sultry, wet air
Clothing	light-weight base layer, short sleeved shirt, trousers, medium-weight skirt, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
13:35	Light activity, standing, 1.4 met	Air movement too low		Coming from outside
15:21	Seated, 1.0 met			Used the wrist cooler
16:15	Seated, 1.0 met			

C4 – Wrist Coolers, DAY 2

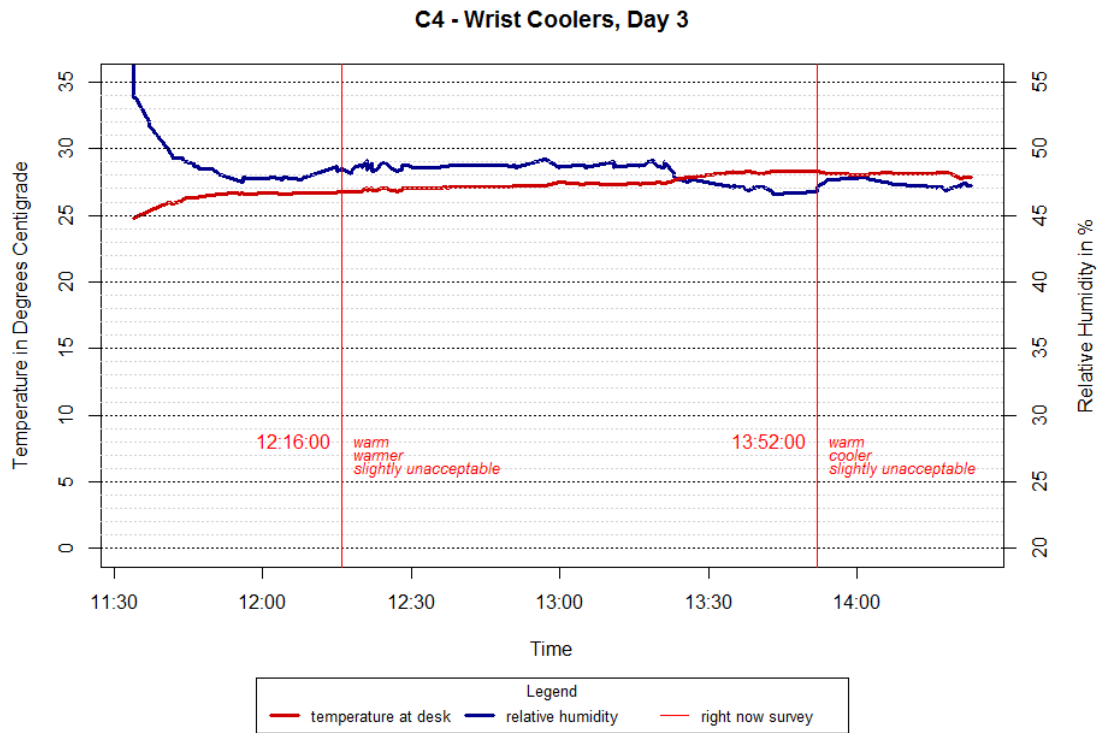


Outdoor Weather	Partly cloudy and windy to cloudy/grey
Clothing	light-weight base layer, medium-weight trousers, dress, socks; jacket

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
13:08	Light activity, standing, 1.4 met	Air movement too low	at room temperature	
16:40	Seated, 1.0 met		at room temperature	
18:13	Seated, 1.0 met			Used the wrist cooler

Comments	(1) "I am hot because I were active before I filled this out."
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C4 – Wrist Coolers, DAY 3

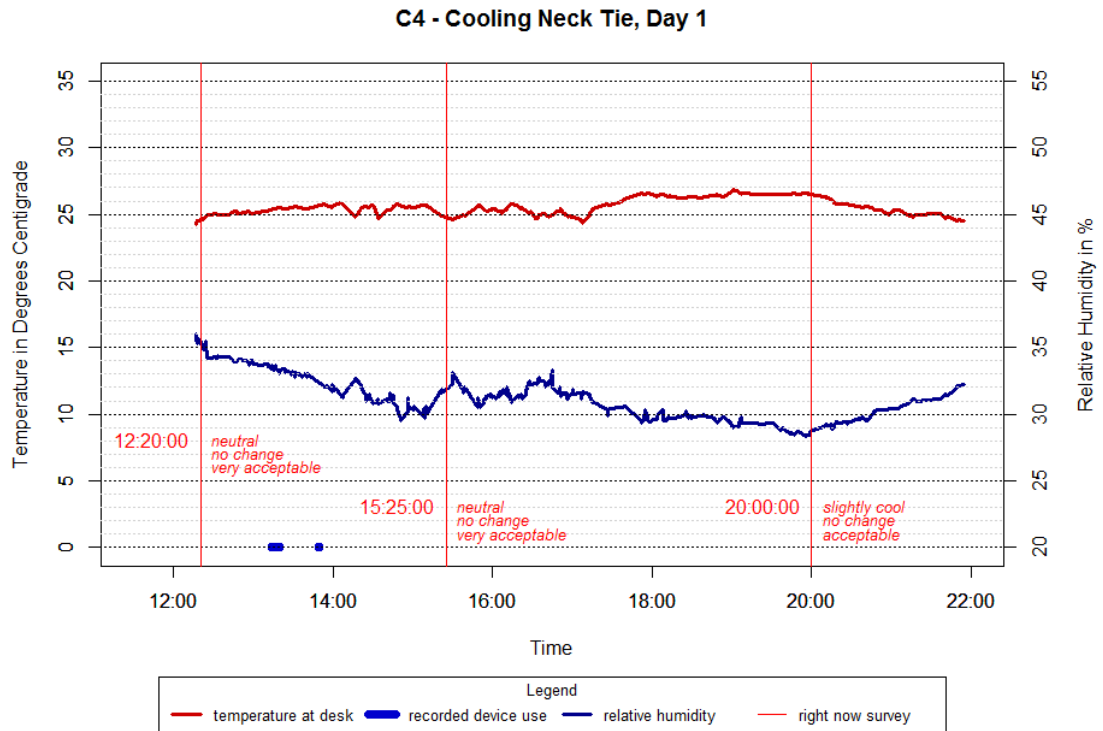


Outdoor Weather	Cloudy/grey and wet air
Clothing	light-weight base layer, tights, medium-weight short-sleeved top, skirt, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:16	Seated, 1.0 met	Humidity too high	Hot and cold	
13:52	Seated, 1.0 met	Humidity too high	Hot	Used the wrist cooler (provided too much cooling)
17:28	Seated, 1.0 met			

Cooling Neck Tie

C4 – Cooling Neck Tie, DAY 1

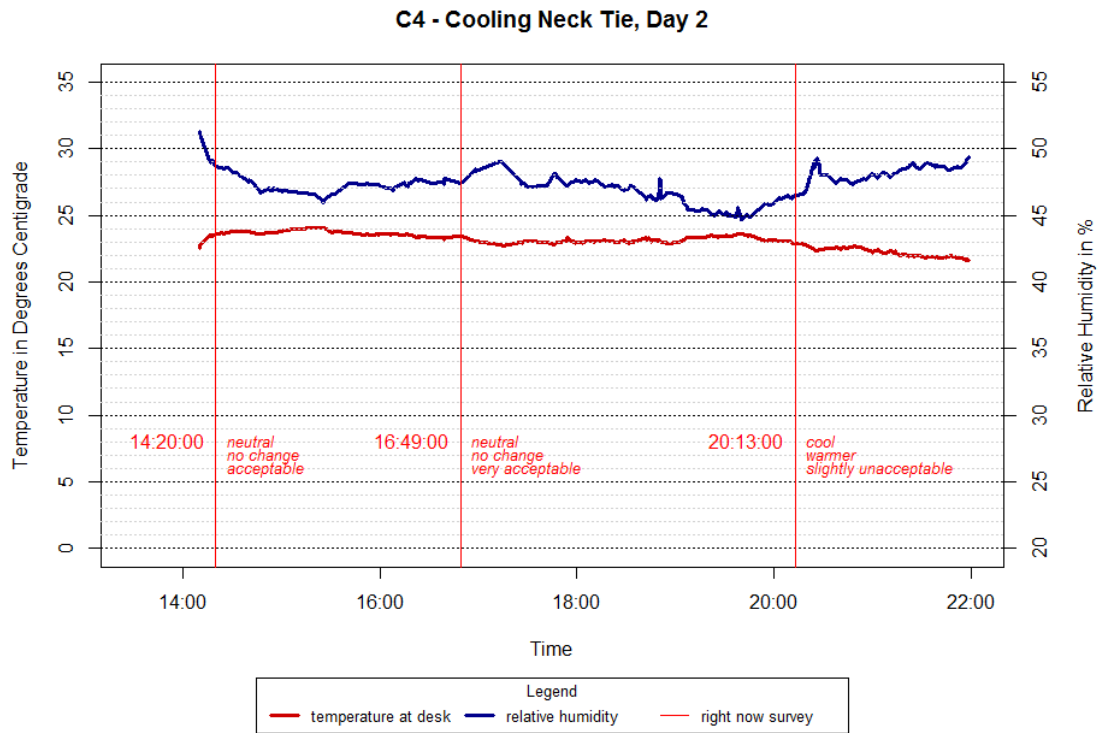


Outdoor Weather	Cloudy/Grey
Clothing	medium-weight base layer, tight, dress, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:20	Seated, 1.0 met			
15:25	Seated, 1.0 met		Cold	
20:00	Seated, 1.0 met			

Comments	(2) "I experienced that I use the cooling mostly when I come back to office and am hot from walking + taking stairs. So I use the device shortly to cool down from that."
----------	---

C4 – Cooling Neck Tie, DAY 2



Outdoor Weather	Cloudy/Grey and rainy
Clothing	medium-weight base layer, tight, dress, socks; sweater, jacket

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
14:20	Seated, 1.0 met			Removed jacket
16:49	Seated, 1.0 met		at room temperature	Added light jacket/sweater
20:13	Seated, 1.0 met	Air movement too high; drafts from windows	at room temperature	Removed sweater

Comments	(1) "I removed the jacket a while ago because I came back from the gym."
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C4 – Cooling Neck Tie, DAY 3

No sensor data was recorded

13:23 Neutral – No change – Acceptable

15:26 Slightly cool – Warmer – Neutral

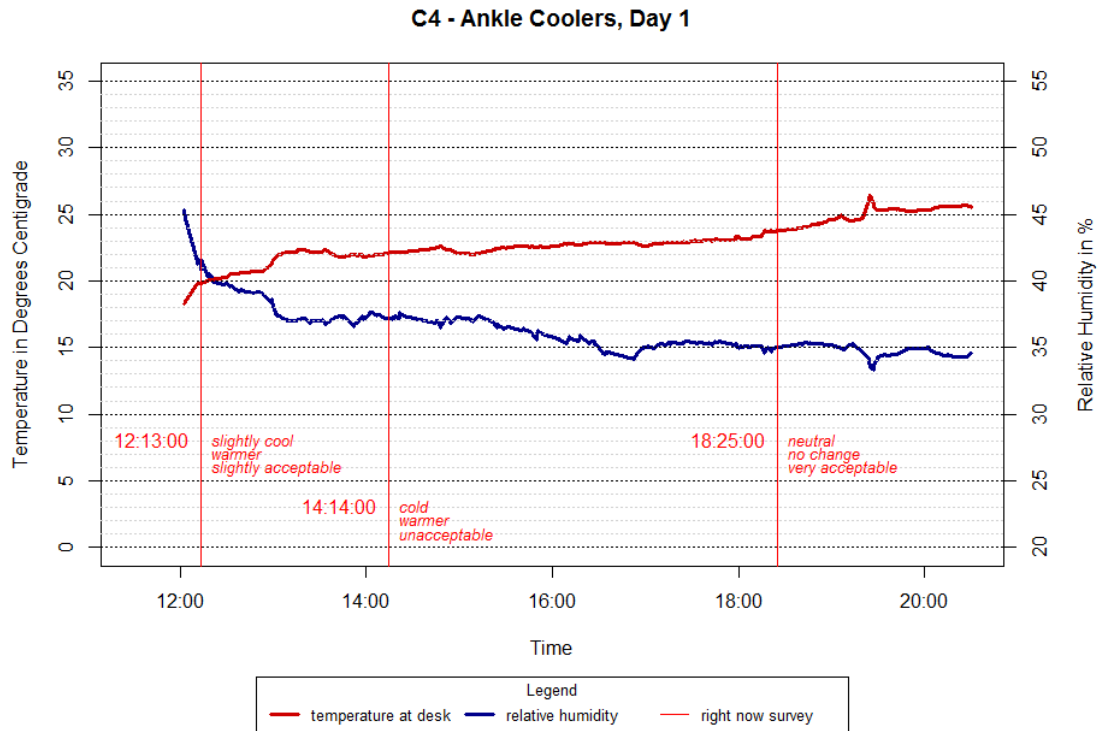
16:30 Neutral – No change – Slightly Acceptable

Outdoor Weather	Partly cloudy and windy
Clothing	medium-weight base layer, long-sleeved shirt, trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
13:23	Seated, 1.0 met			
15:26	Seated, 1.0 met	Air movement slightly too high		Added a woollen jacket
16:30	High activity, walking, 2.0 met			

Ankle Coolers

C4 – Ankle Coolers, DAY 1

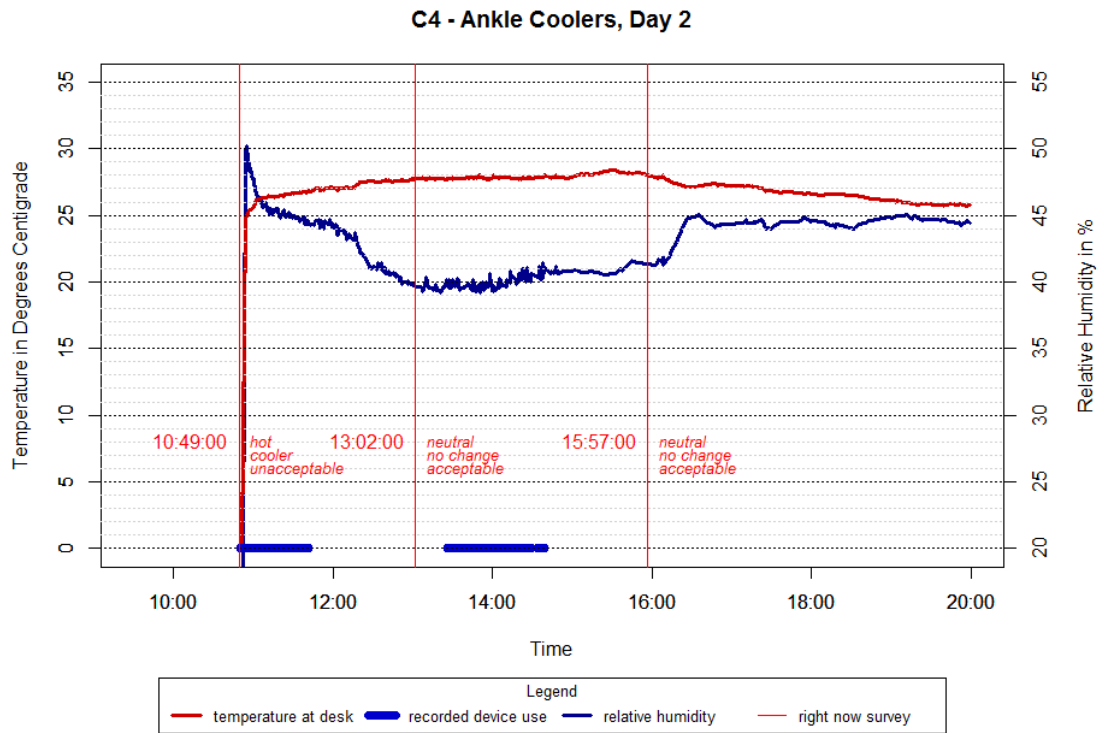


Outdoor Weather	Partly cloudy
Clothing	medium-weight base layer, short-sleeved top, trousers, socks; light-weight jacket

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:13	Seated, 1.0 met	Air movement too high; drafts from windows		
14:14	Seated, 1.0 met	Drafts from windows, no heating		Added another thin jacket
18:25	Seated, 1.0 met		at room temperature	Removed the second jacket

Comments	(2) “Even though I am wearing two thin jackets, I am freezing and have cold hands.” (3) “It was so cold over the day I had to leave the office to work elsewhere.”
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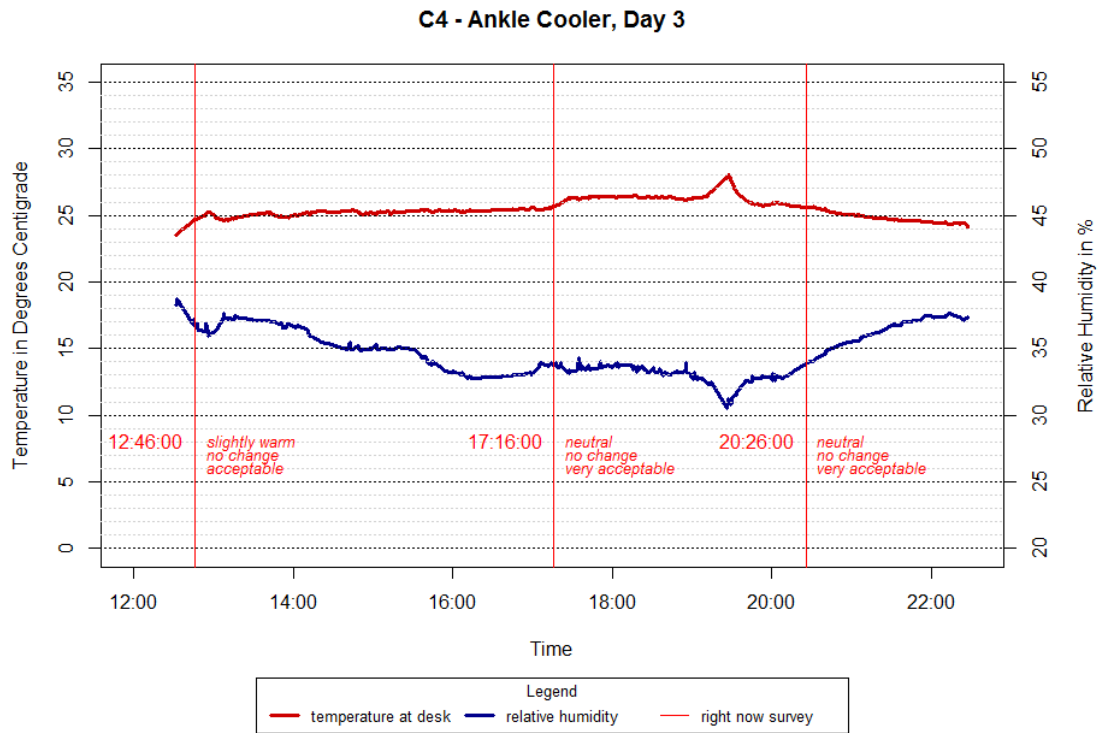
C4 – Ankle Coolers, DAY 2



Outdoor Weather	Cloudy/Grey and wet air
Clothing	medium-weight base layer, short-sleeved top, tights; light-weight skirt, medium-weight sweater

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:49	Seated, 1.0 met	Wet and warm	Hot	Used ankle coolers; removed sweater
13:02	Seated, 1.0 met		Cold	
15:57	Seated, 1.0 met			

C4 – Ankle Coolers, DAY 3



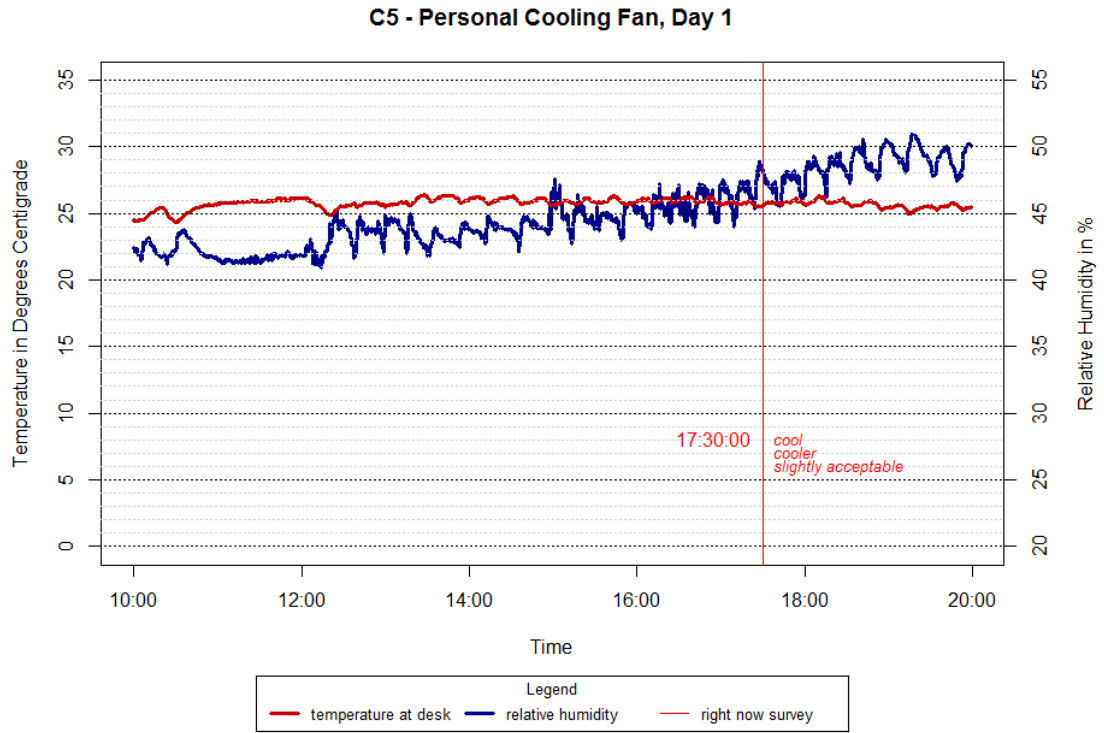
Outdoor Weather	Cloudy/Grey
Clothing	medium-weight base layer, short-sleeved top, trousers, socks; medium-weight sweater

Data Points	Activity Level prior to survey	Environment	Drink/Food	Device Use / Behavioural Adaptation
12:46	Seated, 1.0 met		At room temperature and cold	Removed sweater
17:16	Seated, 1.0 met		Cold	Added sweater
20:26	Seated, 1.0 met			

Participant C5

Personal Cooling Fan

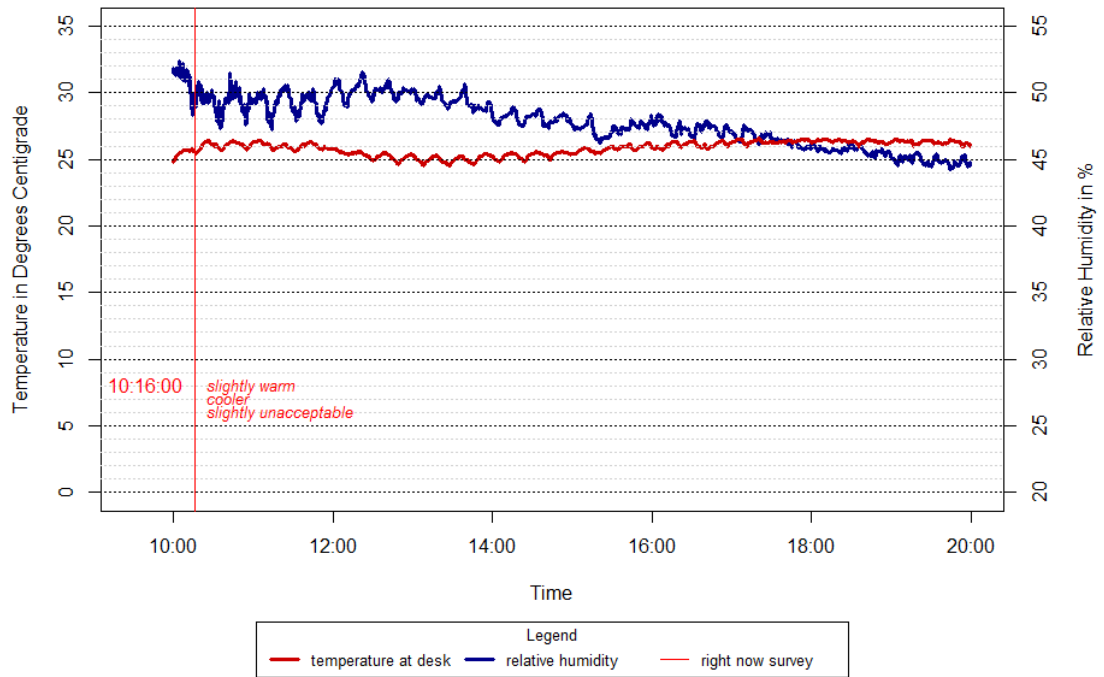
C5 – Personal Cooling Fan, DAY 1



Outdoor Weather	Rainy
Clothing	light-weight base layer, short-sleeved shirt, trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
17:30	Seated, 1.0 met		At room temperature	

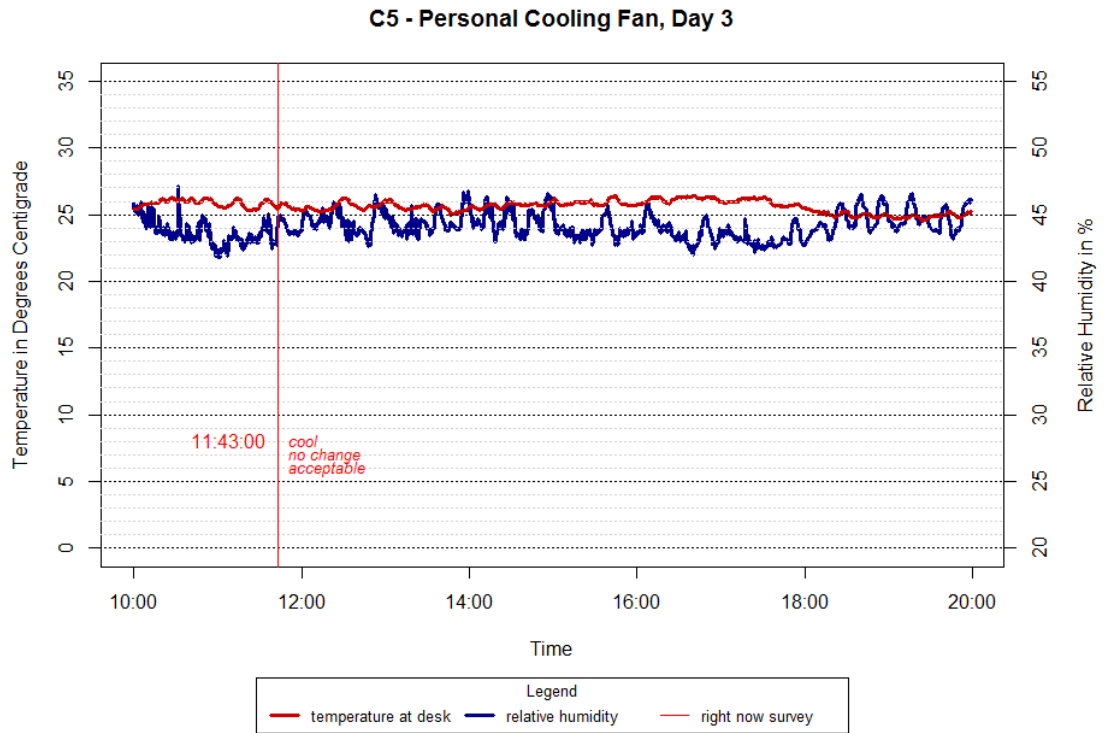
C5 - Personal Cooling Fan, Day 2



Outdoor Weather	Partly cloudy
Clothing	light-weight base layer, short-sleeved shirt, medium-weight trousers, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:16	Seated, 1.0 met	Air movement too low, cooling system provides not enough cooling, too humid	Hot	Used the cooling fan

C5 – Personal Cooling Fan, DAY 3



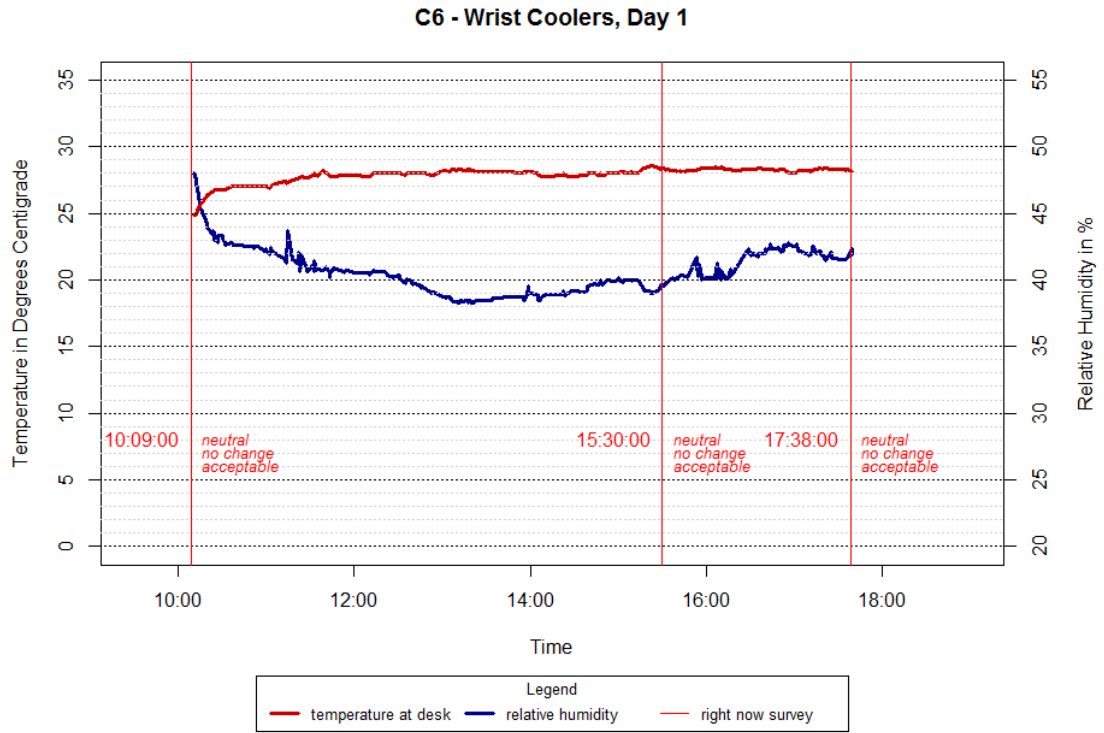
Outdoor Weather	Partly cloudy
Description	light-weight base layer, short-sleeved shirt, socks, medium-weight trousers;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:43	Seated, 1.0 met		At room temperature	Used the cooling fan

Participant C6

Wrist Coolers

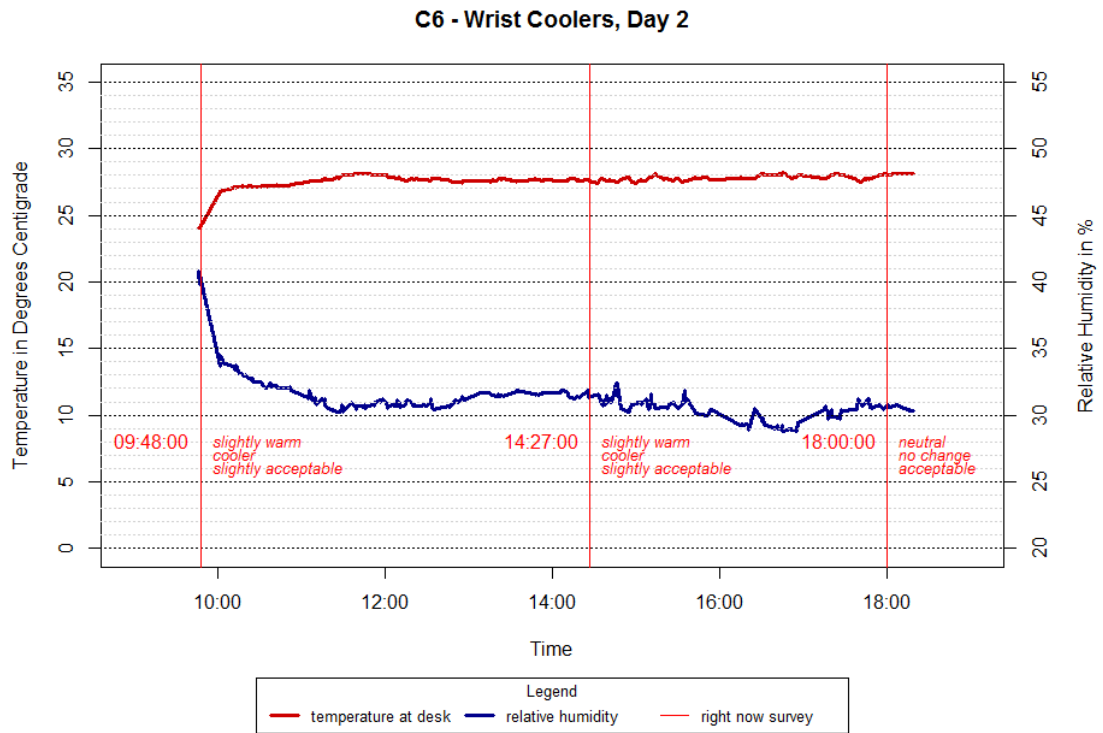
C6 – Wrist Coolers, DAY 1



Outdoor Weather	Partly cloudy
Clothing	light-weight base layer, short-sleeved top, mid-weight trousers;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:09	Seated, 1.0 met		At room temperature	
15:30	Seated, 1.0 met			
17:38	Seated, 1.0 met		At room temperature	

C6 – Wrist Coolers, DAY 2

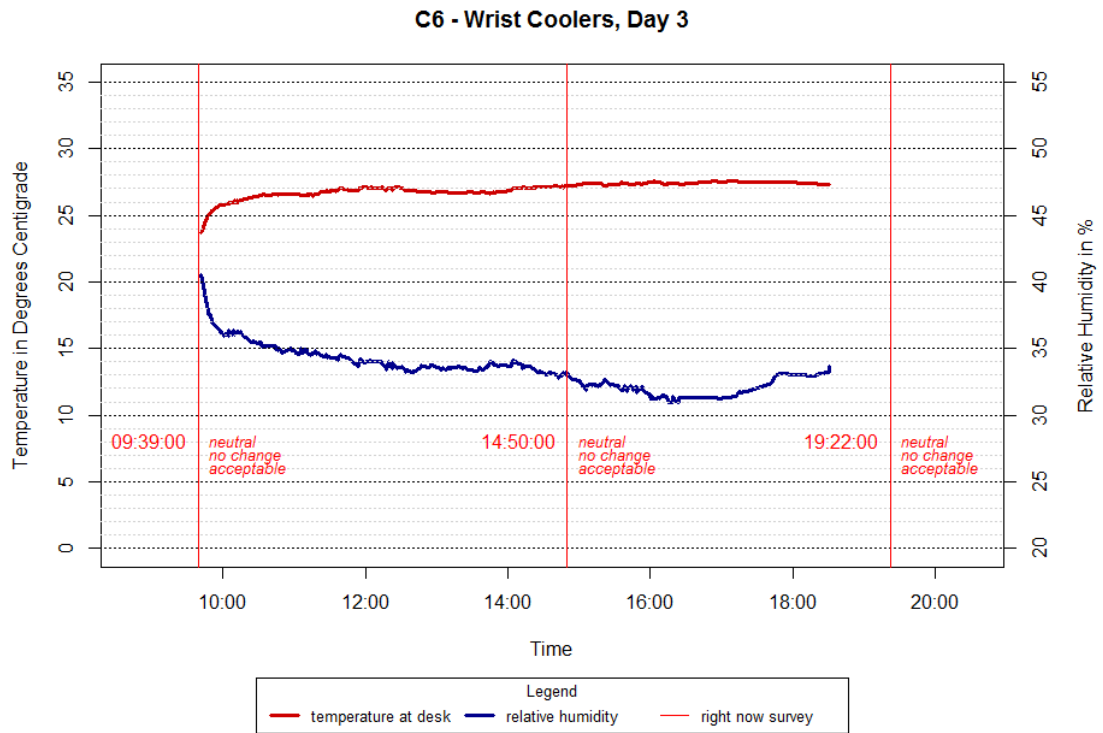


Outdoor Weather	Clear/Sunny
Clothing	light-weight base layer, long-sleeved top, mid-weight trousers;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:48	High activity, walking, 2.0 met		At room temperature	
14:27	High activity, walking, 2.0 met		At room temperature	
18:00	Seated, 1.0 met		At room temperature	

Comment	(3) "I seldomly used the cooling device as today was quite cool."
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C6 – Wrist Coolers, DAY 3



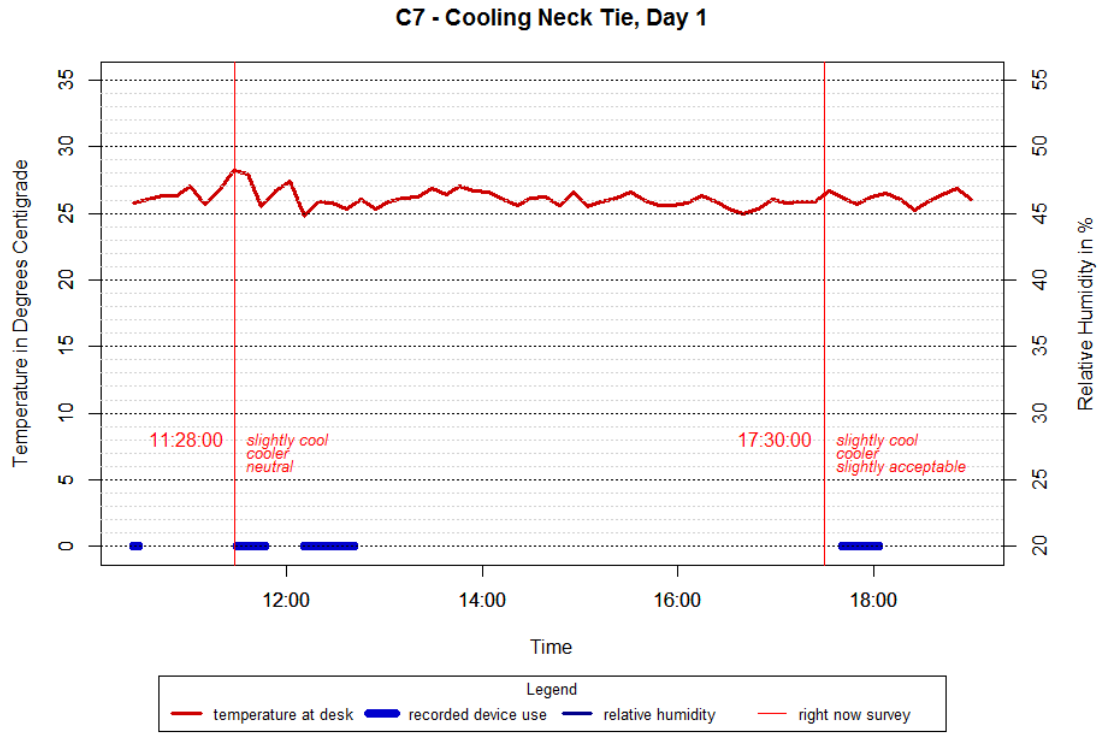
Outdoor Weather	Partly cloudy
Clothing	light-weight base layer, long-sleeved top;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:39	High activity, walking, 2.0 met		At room temperature	
14:50	High activity, walking, 2.0 met		At room temperature	
19:22	Seated, 1.0 met		At room temperature	Added a jumper

Participant C7

Cooling Neck Tie

C7 – Cooling Neck Tie, DAY 1

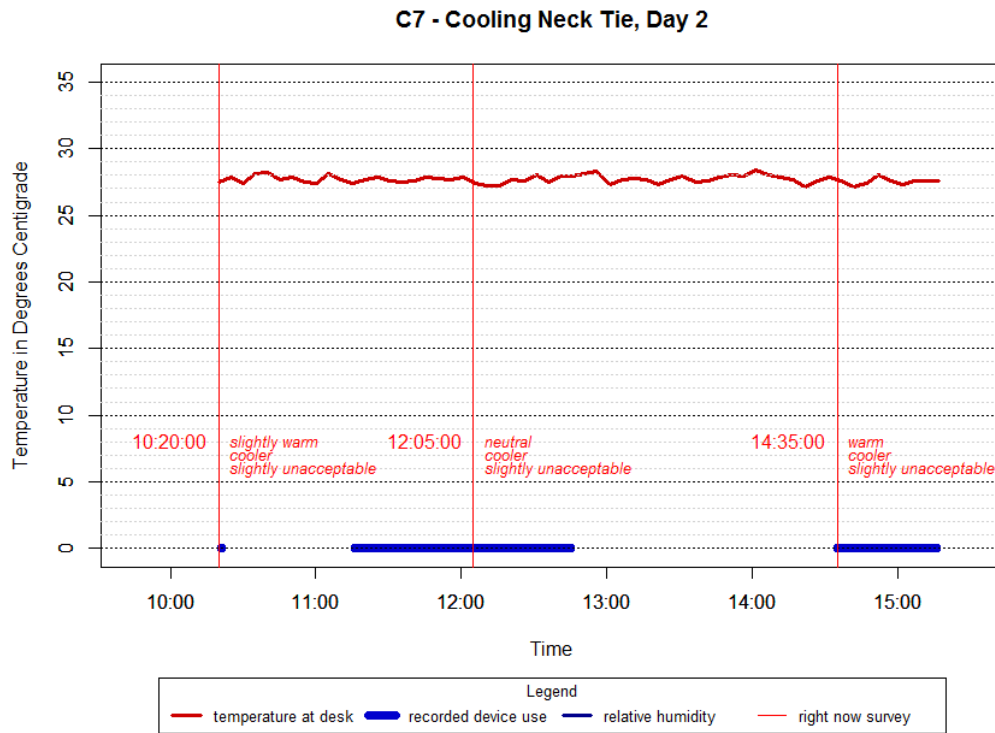


Outdoor Weather	Partly cloudy and windy to Cloudy/Grey, drizzly and windy
Clothing	medium-weight base layer, tights, light-weight trousers, heavy-weight long-sleeved top, socks;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:28	Seated, 1.0 met			
17:30	Seated, 1.0 met			Added jacket

Comment	(2) "I keep the cool bag slightly warm."
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C7 – Cooling Neck Tie, DAY 2



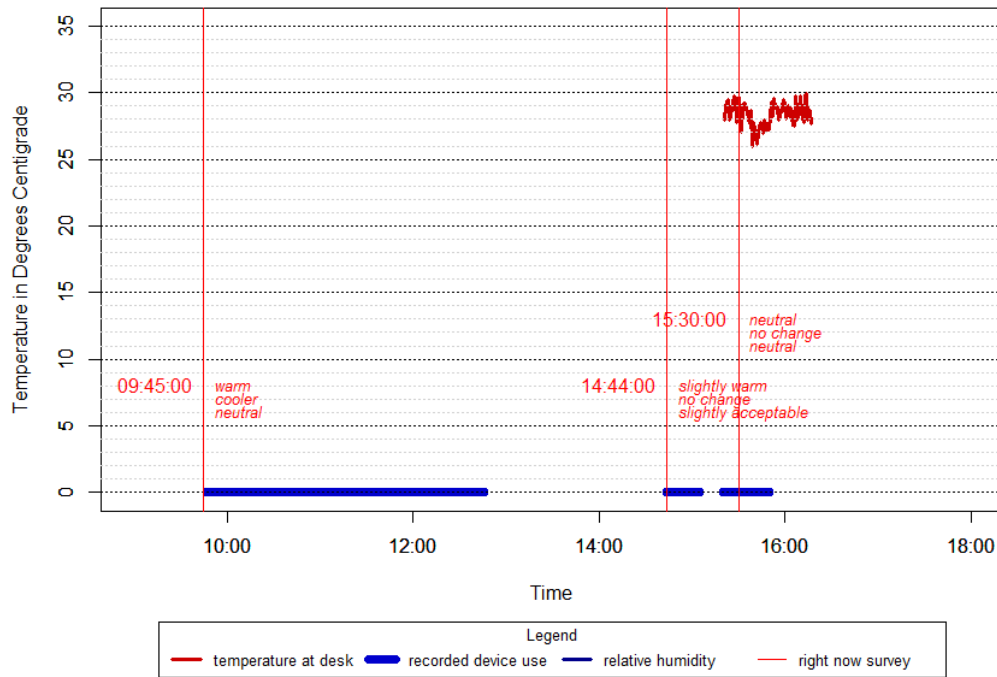
Outdoor Weather	Clear/sunny and windy to partly cloudy
Clothing	medium-weight base layer, light-weight trousers, heavy-weight long-sleeved top, socks; medium-weight jacket

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:20	Seated, 1.0 met	Air movement too low	At room temperature	
12:05	Seated, 1.0 met	Air movement too low		
14:35	Seated, 1.0 met	Air movement too low	Hot	

Comment	(1) “It’s better to have both cooler and warmer setting for the devices.”
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C7 – Cooling Neck Tie, DAY 3

C7 - Cooling Neck Tie, Day 3



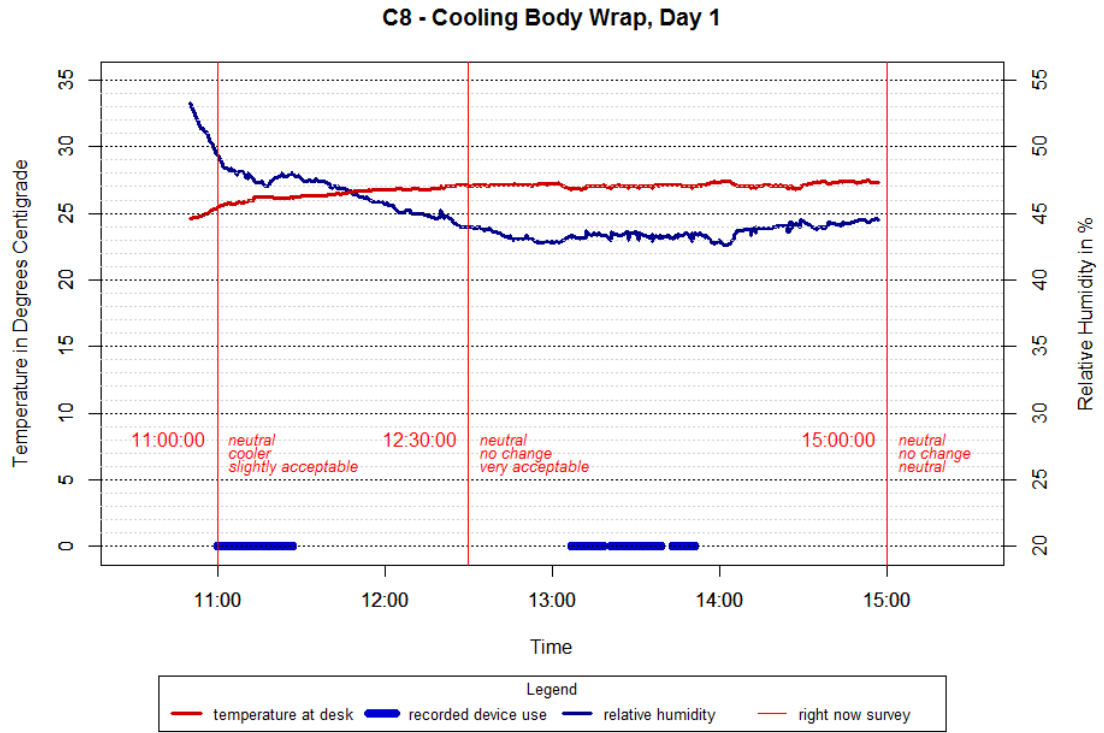
Outdoor Weather	Clear/sunny to cloudy/grey
Clothing	Light-weight base layer, sweater, medium-dress;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:45	Seated, 1.0 met		Hot	
14:44	Seated, 1.0 met			
15:30	Seated, 1.0 met			

Participant C8

Cooling Body Wrap

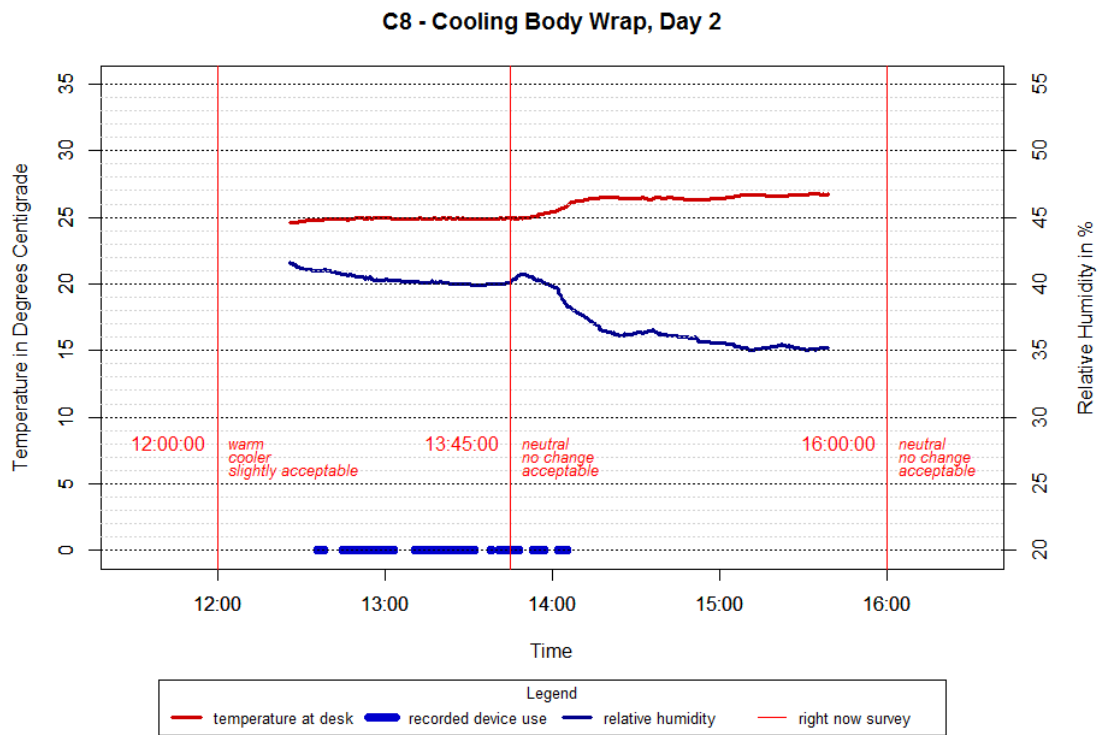
C8 – Cooling Body Wrap, DAY 1



Outdoor Weather	Partly cloudy and humid
Clothing	Light-weight base layer, long-sleeved shirt, socks, heavy-weight trousers;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:00	High activity, walking, 2.0 met		Cold	
12:30	Seated, 1.0 met			Used the body wrap
15:00	Seated, 1.0 met		Cold	Used the body wrap

C8 – Cooling Body Wrap, DAY 2



Outdoor Weather	Partly cloudy
Clothing	Light-weight base layer, socks, medium-weight long-sleeved shirt, heavy-weight trousers;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:00	High activity, walking, 2.0 met		Hot	
13:45	Seated, 1.0 met			Used the body wrap
16:00	Seated, 1.0 met			

C8 – Cooling Body Wrap, DAY 3

No sensor data was recorded

11:00 Neutral – No change – Slightly Acceptable

13:30 Neutral – No change – Acceptable

17:00 Neutral – No change – Acceptable

Outdoor Weather	Partly cloudy to rainy
Clothing	medium-weight base layer, long-sleeved shirt, light-weight socks, heavy-weight trousers;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:00	High activity, walking, 2.0 met			
13:30	Light activity, standing, 1.4 met		Hot	
17:00	Seated, 1.0 met			

Appendix C

Materials Low-Fidelity Study

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C.1. Information Sheet

C.2. Scenario Description

Scenario 1: Heating

It is a cold September day, you are working in your office, but the space heating has not been switched on yet. You have been sitting at your desk for a while already and are starting to feel chilly. You have been given this personal heating device to use. Please talk us through how you would use it.

Scenario 2: Mixed Mode

It is a regular office day. You have just come into the office from outside and you feel slightly hot from walking in the cold and coming into the warm office. You have been given this personal heating / cooling device to use. Please talk us through how you would use it.

Scenario 3: Cooling

It is a warm day outside and the sun is heating up your office. Opening the window does not provide relief. You have been given this personal cooling device to use. Please talk us through how you would use it.

Instructions during Conversation

ON/OFF

- Please switch the device on.
- Please switch the device off.

Temperature Adjustments

- After a while the temperature you originally set starts feeling [too hot/too cold] and you want to adjust it. Please do so.

- The device is providing too much [heat/cooling] and you start feeling too hot/cold. Please adjust the temperature of the device accordingly.
- The device is not providing enough [heat/cooling] and you are still not feeling absolutely comfortable. Please adjust the temperature of the device accordingly.
- You have been sitting for a while and [you/your feet/your hands] are getting cold.

Portability

- It is time for your lunch break and you are planning to leave the office. What would you do with the device?
- It is the end of the day and you are ready to head home. What would you do with the device?

Participatory Element

- How usable and useful did you find the device?
- Do you have any suggestions how the device could be improved?
- Please make adjustments to the device and alter it according to your needs.

C.2. Scenario Description

Scenario 1: Heating

It is a cold September day, you are working in your office, but the space heating has not been switched on yet. You have been sitting at your desk for a while already and are starting to feel chilly. You have been given this personal heating device to use. Please talk us through how you would use it.

Scenario 2: Mixed Mode

It is a regular office day. You have just come into the office from outside and you feel slightly hot from walking in the cold and coming into the warm office. You have been given this personal heating / cooling device to use. Please talk us through how you would use it.

Scenario 3: Cooling

It is a warm day outside and the sun is heating up your office. Opening the window does not provide relief. You have been given this personal cooling device to use. Please talk us through how you would use it.

Instructions during Conversation

ON/OFF

- Please switch the device on.
- Please switch the device off.

Temperature Adjustments

- After a while the temperature you originally set starts feeling [too hot/too cold] and you want to adjust it. Please do so.
- The device is providing too much [heat/cooling] and you start feeling too hot/cold. Please adjust the temperature of the device accordingly.
- The device is not providing enough [heat/cooling] and you are still not feeling absolutely comfortable. Please adjust the temperature of the device accordingly.
- You have been sitting for a while and [you/your feet/your hands] are getting cold.

Portability

- It is time for your lunch break and you are planning to leave the office. What would you do with the device?
- It is the end of the day and you are ready to head home. What would you do with the device?

Participatory Element

- How usable and useful did you find the device?
- Do you have any suggestions how the device could be improved?
- Please make adjustments to the device and alter it according to your needs.

C.3. Questionnaire

ID #

Study Questionnaire

In the following questionnaire we would like to get to know about your individual thermal background and what you usually do to achieve thermal comfort at home and in the office.

Section 1: Background Information

1.1. What is your age?

1.2. What is your gender?

Female

Male

1.3. Would you call yourself a person who easily feels cold, or easily feels too warm, or neither?

1.4. Which of the following best describes your workspace?

Cubicle with high partitions (about 1.5m high)

Cubicle with low partitions (lower than 1.5m high)

Desk space in an open-plan office

Other, please describe:

Section 2: Behavioural Adjustments to Achieve Comfort

2.1. What do you do or how do you adjust to the temperature **if you feel cold**? (*Please let us know briefly for each case if applicable which devices you use, if you put on/off specific clothing, if you make adjustments to the environment, or if you notice any behavioural changes happening about yourself*)

a At home

ID #

b In the office

2.2. What do you do or how do you adjust to the temperature **if you feel hot?** *(Please let us know briefly for each case if applicable which devices you use, if you put on/off specific clothing, if you make adjustments to the environment, or if you notice any behavioural changes happening about yourself)*

a At home

b In the office

Section 3: Personal Heating / Cooling Device

3.1. What from your point of view is the greatest challenge you face in achieving thermal comfort in your workplace?

3.2. This project is exploring personal devices for heating/cooling and achieving individual comfort. What from your point of view would be the greatest challenge using such a device in the office environment?

Thank you very much for your participation!

C.4. Interview Transcripts

Participant L1

TC	ID	Conversation	Gestures
00:01	I	Okay, so the scenario I'm going to give you is this one. I will give it to you to read. So, it's a cold September day and you are working in your office, but the space heating has not been switched on yet. You have been sitting at your desk for quite a while already and are starting to feel chilly. You have been given this personal heating device to use. Please talk us through how you would use it and if.	
00:31	L1	Okay. Yeah, I would definitely use it. I would... You grab it here and you stick it together like so, yes?	L1 picks up the fan with the left hand and sticks the control element on top of it with his right.
00:42	I	Yes.	
00:43	L1	And I would need heating, which mean I would do this. Am I doing your job here?	L1 picks up the heating layer and adds it to the control element.
00:54		Then I think if I was at my desk I would most likely have it sat on my desk. It would probably... Turn it up to, if I can turn it.	L1 turns the fan prototype in his hands and then tries to adjust the setting of the control element.
01:12	L1	To say... I need to turn this don't I?	L1 is trying to adjust the setting by turning the indicator layer on the control element.
01:15	I	Yeah.	
01:16	L1	There we go. So, you turn it to - first of all, since it was my first time using it, I would turn it to half way and see how that goes.	L1 manages to turn the indicator layer. It is set half way on the scale.
01:26		I would probably have it at the side, if I'm working at my desk, so that I can feel it when I'm on my keyboard.	L1 places the fan on the desk next to him, to his left. The fan is on the same level as his hands. He moves his fingers indicating typing.
01:34	I	Yes.	
01:36	L1	I would probably give it quite a good time before I... a good twenty minutes before I sort of would think about adjusting it I suppose. See how it feels. Then I would decide it is quite settled.	L1 gestures with his hands.
01:48		Clearly if I was going to change the temperature, I would just grab it because it is quite close to me and adjust it, like so.	L1 grabs the fan with his right hand. He indicates a turning movement over the control element with his left hand.
02:00		Chances are I would not be using the cooling one once at all, because I'm feeling chilly. I am not going to do that.	L1 points towards the cooling layer. He puts the fan prototype back in the same position as before.
02:07		I always feel the cold on my hands; therefore, that is why I would have it here.	L1 puts his hands slightly up in front of him, wiggling his fingers.

TC	ID	Conversation	Gestures
			He briefly touches the fan prototype with his left hand.
02:10		I might swap it over, give the other hand a go.	L1 picks up the fan prototype and places it on the same level at his right side.
02:13		I probably would never have it here.	L1 picks up the fan prototype with his right hand and places it in the centre, facing the imaginary keyboard.
02:17		If it was a desktop machine, which actually had a desktop on the desk and the monitor above, which not many of them do now. But I would probably have it... If you can put it above the keyboard, then that would be fine.	L1 outlines the setting with his hands: a desktop computer horizontally placed on the desk in front of him with a monitor sitting on top. He then holds up the fan prototype in front of him so that it would be sitting on top of the desktop computer pointing towards the keyboard.
02:30		I would probably never use the app for it, because it is within reaching distance. I would much more likely just grab it and use it that way.	L1 points towards the app interface. L1 moves the fan from one place to another.
02:42		If I'm working at my desk, I wouldn't see no need for having it attached to me because I'm not going to be moving around and I would just work with it like that.	L1 points towards the wearable prototype.
02:51	I	Okay, that's great.	
02:53	L1	Okay [laughs].	
02:55	I	Yes [laughs]. And now it is time for your lunch break and you are planning to leave the office pretty much. What would you do with the device?	
03:05	L1	Switch it off.	
03:07	I	You would switch it off.	
03:08	L1	Yes, I would definitely wind it down. I am breaking it. So...	L1 picks up the fan and turns down
03:26		And unplug... Here we go and I would just leave it like that.	L1 removes the heating layer from the control and puts it in front of him. He places the fan prototype on his left
03:31	I	Okay cool.	
03:32	L1	And go away, and I would just do the opposite when I came back.	
03:36	I	Okay.	
03:37	L1	I would expect to have a better idea of what temperature to set it at because I had spent the morning with it.	L1 points towards the fan prototype.
03:41	I	Okay, cool. That's great. Okay, that is already basically the scenario. We could actually do another one, if you like.	
03:55	L1	Yes, no problem. Let's go.	

TC	ID	Conversation	Gestures
04:00	I	So, we are going to do this one. It is basically the opposite of the previous one. It is a warm day outside and the sun is heating up your office. Opening the windows doesn't provide relief from the heat basically. You have been given this personal cooling device to use. Please talk us through how you would use it.	
04:28	L1	Okay. Right. Then I would grab the cooling element and put that in. Then again turn that up to sort of halfway two thirds, just to gauge how cool it would be. Now for me I wouldn't have it pointing at my hand I would have it pointing at my face, somehow. So I would probably get... If I was at my desk it would most likely be some combination of books or something like that, that I could angle it, so that it was going towards my face. I don't like cold on my hands at all but on face cooling it is great. So that is pretty much how I would use it. I would adjust the setting after spending ten minutes, 15 minutes, 20 minutes should I need to and if I felt sufficiently cool I would switch it off. Unlike the heating one, knowing me I would just leave that on and on and on, because as soon as you switch it off you would be cooler. But the cool one, I would say as soon as I felt, right I'm cool enough I would probably either turn it right down or very low or switch it off.	L1 picks up fan prototype
	I	Okay. So let's say you are feeling cool enough already and just need a little bit more cold.	
	L1	So yes, I would...	
	I	Show us how you would adjust.	
	L1	Again, if I was at my desk I wouldn't bother with the app. So, you adjust it down to maybe sort five ten percent of running. Again, I would put that back out again, angle it, so that it was going up the way. Or if I could put it on top of a monitor or something like that, that is up there that would be great as well. How I would detach it I am not sure, but that is one consideration I would look for. In my office there is a window ledge, so I might put it on the window ledge.	
	I	Yes.	
	L1	I would again think if I was using it for heating I would have it closer. If it was cooling I wouldn't feel too bad with it being out of arms reach so far. But I'm more sensitive to the cold so.	
	I	Yes.	
	L1	Some people are the other way around; some would have it really close to them.	

TC	ID	Conversation	Gestures
	I	Okay cool. Now it is the end of the day and you are ready to go home. What would you do with the device?	
	L1	It is the end of the day.	
	I	It is still a hot day.	
	L1	In fairness I would probably just leave it in the office. I would switch it off as so, just quick. Turn around and click. The cooling element out, put that on the desk and leave it until the morning if that is the end of the day.	
	I	Okay cool.	
	L1	Yes.	
	I	Yes, thank you so much.	
	L1	Okay.	
	I	So, the next thing is how usable and useful did you find the device and are there any alterations that you need or you think?	
	L1	Yes, the device would be useful. I would say depending on how you are powering it. Is it something you are going to have plugged in or is it going to be in batteries or anything like that? That kind of certainly has a lot of influence over how mobile it is. But even if both the scenarios you have given me are office, I would maybe think USB powered would probably work quite well. You know and then something like a clip or just even an angled bracket. So either you could sit it on a monitor or you can just lean it back.	
	I	Okay.	
	L1	Like that, that would be something I would look into. So basically what I mean is angled up and it comes down to two thirds of a way. So it can lean at an angle, it can hang on something.	
	I	Okay.	
	L1	The board [inaudible 0:08:48] can sit flat. It gives you sort of a couple of options.	
	I	Okay.	
	L1	That is how I would think about it. If it was battery operated I would suggest then... Yes, if would most likely if it was cooling, it would go some distance away. If I got into that scenario and say you are working in an office plan office, like the one we are in, and I go and speak to someone that is where the app might come in.	
	I	Okay.	
	L1	But if I was at my desk I probably wouldn't use the app at all.	
	I	Okay.	

TC	ID	Conversation	Gestures
	L1	But that is the only thing I can think of.	
	I	Okay, that's perfect. Could you prototype the angle like briefly? Because this is why [inaudible 0:09:38].	
	L1	Alright sure.	
	I	In a simple way.	
	L1	Is there something I should be cutting?	
	I	Yes you want to.	
	L1	So what I'm thinking someone... Some sort of manufactured plastic you could probably make here that, something along the lines of [pause] the angle is maybe a little bit [inaudible 0:10:41]. So it is sat something like this and then could just lean back like that or you could hang it onto something like that. Maybe more acute angle than that but thinner and something that still lets air comes in the back, but just has a lid that hangs over.	
	I	Okay.	
	L1	Sorry for destroying that [laughs].	
	I	No no [laughs]. Thank you so much.	
	L1	Okay.	
	I	Okay, that is already it basically.	
	L1	Cool.	
	I	So thank you very much. I just have one questionnaire to fill out. It is two pages.	
	L1	Thanks.	
	I	Thank you.	

Participant L2

Time	ID	Conversation	Gestures
	I	So, we have the following scenario. It is a regular office day. You've just come into the office from the outside, and you feel slightly hot from walking in the cold.	
	L2	Right now.	
	I	Yes, and coming into the warm office, you've been given this... oh, I forgot to explain to you how it works. I'm sorry.	
	L2	That's okay.	
	I	It's because it's the first one this morning. So, I'm going to do this first. So, the idea is that you have, like, a heating and cooling source, which this one symbolises. So, there would be buttons where you can switch between heating and cooling.	
	L2	Is that a wearable device?	

Time	ID	Conversation	Gestures
	I	Yeah. I'm going to get to this in a second. So, it's a modular system. So, this is the heating and cooling source. By turning, you can adjust the heat or cold, and here, a light would indicate if it's heating or if it's cooling, and, yeah, this is basically low to high, and this is on/off in the middle.	
	L2	So, it's one button, on/off? So, it's two switches. One is this switch, and this is the on/off. What about this button?	
	I	Yeah. So, there would be switching between heating and cooling, because it can do both. Like, it's hypothetical.	
	L2	Yeah, okay.	
	I	Yeah, but this needs to be used with either a fan... so, you would attach it to this fan device, and then you would use it, like, switch it on basically, and then it would blow hot or cool air, or you can wear it with a garment. So, you can choose generally. So, the idea is that the heat and cold would distribute across the...	
	L2	No air here?	
	I	No air, no. This is air. This is, like, a cloth that would heat or cool down, but you would have to put this on top as well. So, yeah. Alternatively, you can control the device on an app.	
	L2	Excellent.	
	I	This is very basic. So, you can switch it on here, and then adjust the temperature, cool us down.	
	L2	The slider, yeah.	
	I	This heating is up, and it also has some additional screens. So, the screen will change when you use it. So, this is 'off' mode, yeah. Do you have any questions?	
	L2	No. That's fine.	
03:09	I	Okay. So, back to the scenario. So, it's a regular office day. You have just come into the office. You're feeling hot from walking, and you come in from the cold to the warm and feel a bit warm, and you have been given this device, which you can use. So, please talk us through how you would use it.	
03:30	L2	So, I have two options, right? Either to attach it here or to wear it. [brief pause]	L2 briefly places his left hand over the fan on his left and then uses his left hand to briefly touch his jumper.
03:41		I think I would attach it here, and the reason is that I don't have the feeling of how that works, how that feels attached to myself.	L2 touches the fan with his left hand. Then he hovers over the control unit with his left hand and moves to touch his jumper.

Time	ID	Conversation	Gestures
03:50		Although I can assure you that this would work with cool air, but I'm not sure about the hot air facing myself, maybe too dry or something. But yeah, I think that's it.	L2 indicates towards the fan. Then he gestures wind coming towards his face.
04:03	I	Okay. So, can you just do it for me?	
04:06	L2	Okay. You said that that's heat from the other side, like that. Then I would control it to, let's say, up to here, and I will enable it and I will make sure that the cool button is here. So, something like that.	L2 picks up the fan prototype and attaches the control unit to it. He turns the dial to about 45%, slightly below half-way. He attaches to cooling element.
04:34		I do have a comment though, but maybe it's related to the app. It's weird I think that you have a switch here to separate cool and hot, and here you don't have that.	L2 indicates towards the app prototype with his right hand while holding the fan prototype in his left hand. He briefly indicates to the fan prototype before pointing on the app interface.
04:43		Here, you just separate that by the slider.	L2 moves his right index finger up and down the slider on the app interface.
04:46		You could map exactly the same thing, I think, to this.	L2 points towards the fan control and moves his finger up and down over it.
04:49	I	Okay, yeah, that's a good comment, thank you. So, yeah, where would you place it, once it's hot?	L2 puts down the fan prototype on the desk, to his left, facing him and leans back.
04:56	L2	I think my desk is up to here, so it would face it like that, as it was guided through.	L2
05:05		I could also configure the inclination. Is that the right word? Yeah. So, like that, facing me. You should talk to Jo about that.	L2 puts the fan prototype down and tilts it to different angles.
05:16	I	About to who?	
05:17	L2	To Jo.	
05:18	I	To Jo, yeah, that's true. Okay. Now, you've been sitting at your desk for a while, and, yeah, you're now starting to feel a bit cold. So, your body temperature has gone down. So, what would you do?	
05:37	L2	I'll definitely first try to change that, to configure it to be more hot, I think. Oh yeah, it doesn't work here, so you need to either have cool or cold.	L2 reaches for the fan prototype with his left hand, picks it up and turns it to look at the control unit.
05:51		So, I'll change the switch here, and then take that one, and enable it, and adjust it just a bit, I think. Something like that. Not too hot.	L2 touches the imaginary switch of the fan prototype and exchanges the cooling for the heating element. He presses the button and places it back on the desk. He picks it up again and adjusts the dial to about 20-25%. Then he places it back on the desk.

Time	ID	Conversation	Gestures
06:12	I	Okay. That's fine. Okay, and then it's time for your lunchbreak, and you're planning to go out for lunch. So, what would you do? So, your device is still on.	
06:29	L2	I'd just press it like that. Switch it off.	L2 presses the button on the fan prototype to switch it off.
06:31	I	Okay, that's cool. Okay, thank you. So, that was the first scenario. I think we can do another one, if you like?	
06:46	L2	Yeah.	
06:46	I	So, I'm going to do this one. Okay, so it is a cold September day, and you're working in your office, but the space heating has not been switched on yet. You have been sitting at your desk for a while and are already starting to feel chilly. You have, again, been given this device to use, and please talk us through how you would use it.	I puts the scenario description before L2.
07:19	L2	If it is a cold September... Am I just arriving at the office or am I already working?	
07:23	I	Yeah, you have been working for a bit.	
07:27	L2	I think what I would do is change that, of course, to the heat part, enable it and then change that to maximum...	L2 picks up the fan prototype with his left hand, touches the switch and presses the button to switch it on. He turns the dial to its maximum.
07:36	I	Maximum? Good, okay.	
07:38	L2	Yeah. For a while. Oh, and I have also the option to attach it to myself though, but the only problem with that is that I don't have a feeling of how that will work. I don't understand it, how that will work.	L2 places the fan prototype to his left on the desk. He briefly touches his jumper.
07:50		With the air, I can understand that it flows around you and makes you feel hot or cold, but it would be very, very interesting to attach it to myself to see how that would work, because, with air, it makes your face a bit dry, I think.	L2 makes a circling movement with his left hand in front of his upper body to indicate airflow. He briefly points towards his jumper.
08:04	I	Yes. So, where on your body would you put it, if you try out the wearable?	
08:15	L2	I think chest or belly or something. [brief pause] Belly, I think would be really nice.	L2 touches his chest and then his belly.
08:24	I	Okay. No, that's good. Okay. Would you test it using something like this, just for the...?	
08:34	L2	Yeah, okay. Do you want me to test it?	
08:37	I	Yes, please do, and if it was like... yeah.	L2 picks up the cloth and opens it to its full size in front of him.
08:42	L2	Okay. Let's see, how it works, is that a cloth or is that the device itself?	L2 puts it down at its full width in front of him.
08:48	I	That's the cloth. Yeah, so this would be your cloth. That's just distributing heat or cold. So,	

Time	ID	Conversation	Gestures
		then it only works with this basically, and when there is this source attached.	
09:02	L2	Yeah, that would be amazing. If you could distribute the cold or heat, it would be very, very nice. So, I'd just attach it like that.	L2 removes the control unit from the fan prototype and places it on the cloth in front of him.
09:11		And then I wear it like that, or maybe inside my clothes or something. Is that enough? I can do more if you want.	L2 picks up the wearable prototype and wraps it around his belly.
09:20	I	No, that's fine. Thank you so much. So, yeah, and, in that case, it would be the end of the day, the working day, and then, if you were wearing that, you'd prepare to leave. So, what would you do with the wearable?	L2 removes the control unit from the cloth and places it on the table. He assembles the cloth and puts it on the table to his right.
09:42	L2	I'd just remove it and press the button to stop it.	L2 presses the button on top of the control unit.
09:46	I	Okay, and you would leave it in the office or...?	
09:49	L2	Is it expensive?	
09:52	I	I don't know.	
09:55	L2	Yeah, I would maybe lock it in my drawer.	
10:00	I	Okay. So, cool, thank you very much. Those were the scenarios, and, yeah, now you've used the prototype, do you have any suggestions, how you'd alter it?	
10:17	L2	I think you don't need this switch here, cold or hot. When we say 'cold', it's something like air conditioning, hot?	L2 points towards the imaginary switch below the control unit.
10:29	I	What do you mean?	
10:31	L2	Is it like the air conditioning producing really hot or is it just the fan that makes it...?	L2 moves his hand in a circle.
10:37	I	Yeah, in this case, it's the fan that's warming.	
10:42	L2	Yeah, I don't think you need this switch here, really don't need to, and I have seen that, how the cloths are working, let's forget the air conditioning because you are not using that.	L2 picks up the control unit and points towards the imaginary switch at its bottom.
10:53		When you have it on the minimum, it's just the... no. Oh, this is also the strength of the fan, right? Yeah, they have two calibrators that you need to adjust. Is the front fan level always constant?	L2 turns down the dial to the minimum.
11:14	I	You mean the speed?	
11:16	L2	The speed, yeah.	
11:17	I	To be honest, I haven't thought of that yet, but, yeah, actually, you're right. So, there's two.	
11:24	L2	I think you should remove one of the switches, and you should definitely, I don't know, have you seen this Nest thing?	
11:30	I	Yeah.	
11:31	L2	Okay. Yeah, it would be very nice if it just had one, and that's the reason also, because you can	L2 touches the app prototype with his right index finger while

Time	ID	Conversation	Gestures
		map the app here, oh, and you need a switch here as well.	still holding the control unit in his left. He moves his finger between the app and the control, then puts down the control unit. He points towards the app.
11:43	I	Okay. Could you draw that for me? I don't know, so, for example, if it stays like this, and here you've got the...	
11:56	L2	Okay, let me think. [brief pause] Yeah. I like the circle design very, very much. I think it should be something like that. It's a tough one. Is that the screen or a control? Can it change cold, for example?	
12:44	I	I mean, I haven't prototyped it to that level yet, so it could do anything, basically.	
13:01	L2	Maybe if you start like that, okay, and here it's cold, and then becoming... but that's not actually good, because, again, you are controlling both the heating and the strength of the speed of the fan, but if that's what you need, if the speed itself is the cooling thing, and this is just the level of how hot the air is, it might look something like that. The current design, what they have is just a switch that says... I think it just says enable... no. No, that's for the air conditioning. I don't know. You need two switches, one is to control the speed of the fan and one is to control the temperature, and I'm talking about the temperature of the hot air. So, I think you need two switches for something. The same here. I cannot be very useful, sorry.	
	I	No, that's already very helpful, don't worry. So, already the comment that I need. All this is very helpful to me, actually. So, don't worry. Thank you very much. Thanks a lot.	
	L2	No problem.	
	I	Yeah, this would be it and I do have, like...	
	L2	...a questionnaire, yeah.	
	I	...a questionnaire at the end. So, thank you.	

Participant L3

TC	ID	Conversation	Gestures
00:07	I	So, it will be this scenario. It is a regular office day. You have just come into the office from the outside, and you feel slightly hot from walking in the cold and coming into the warm office. You have been given this personal heating/cooling device to use, and now please	

TC	ID	Conversation	Gestures
		talk us through how you would use it, and if it you would use it.	
00:29	L3	Okay, and now I feel slightly hot. So, I want the office to be cooler. So, I'm going to switch on.	L3 switches on the control unit, which is lying in front of her, reaches for the cooling layer and puts it inside the control unit prototype.
00:58		So, maybe just a bit...	L3 turns the up the dial to about 30%.
01:09		and I like to use this as well... Cooler!	L3 attaches the control unit to the fan prototype. She places the prototype to her front left side and gestures air movement coming toward her from the fan.
01:25		Or maybe I can use this app and set the temperature. Oh, switch on, and set temperature to this level.	L3 looks down on the app prototype in front of her, briefly presses down with her right index finger and then indicates a value on the slider.
01:37	I	Okay. So, yeah, that just turns it down further down. Okay, so we're here.	I changes the app screen and marks the level L3 set the cooling to.
01:46	L3	Yes, and this is a warm office, and, after cooling down, now I feel better. I feel better, I will like to turn this up to the middle and just switch off.	L3 moves the slider on the app to neutral temperature. I marks the setting on the screen. L3 removes the control unit from the fan and presses the on/off switch. She then removes the cooling layer.
02:25	I	Okay. So, but now, after a while, you start feeling a bit cold. So, what would you do then?	
02:40	L3	I feel a bit cold, but I don't want to make all the office warm. I may just warm myself.	
02:52		So, okay, turn it up, and also to this level.	L3 switches on the control unit and puts in the heating layer. She points to the level (30%) that she set previously.
03:03		I would like it from this direction to make me hotter, yes.	L3 reaches for the cloth and puts the control unit on top. She picks up the wearable prototype and places it at the back rest of the chair. She holds it in place while she slightly leans back.
03:20	I	Okay. So, now it's time for your lunchbreak, and you like to go out for lunch. So, what would you do with the device?	L3 puts the prototype back on the table and places it in front of her.
03:35	L3	Just turn it off. Turn off everything.	L3 presses the on/off switch on the control unit. She removes the heating layer and turns the dial to zero. She removes the control unit from the cloth and puts the cloth aside.

TC	ID	Conversation	Gestures
04:08		And also turn this off.	L3 reaches for the app and switches it off. I changes the app screen accordingly.
04:19	I	Okay, thank you very much. So, we can do one more scenario.	
04:21	L3	Okay. Yes, I'd like to.	
04:25	I	So, okay, it's this one. It is a warm day outside, and the sun was heating up your office. Opening the windows doesn't provide relief, and you've been, again, given this heating/cooling device to use. Please talk us through how you'd use it.	
04:42	L3	Okay. Just cool down, and maybe, if it's really hot in my office, and I would like to use all of them, like turn on.	L3 makes an all-encompassing gesture, picks up the control unit and presses the on/off button. She puts the cooling layer into the control unit.
05:07		Sorry. Yes, to this level.	L3 adjusts the dial setting on the control unit but struggles a bit with the clip holding the layers. She points to the setting, which is at about 80% before putting the control unit down.
05:29			She picks up the control unit and puts it on the fan. She places the fan right in front of her and indicates air flow coming towards her.
05:35		And turn on. Set to a lower level. Yes.	L3 reaches for the app and switches it on. She exchanges the screen for cooling and changes the cooling volume on the slider.
05:57	I	Okay, thank you very much. So, then it's the end of your working day, and you're ready to go home. So, what would you do then?	
06:11	L3	Okay. I would make sure everything, I will turn them off.	L3 removes the control unit from the fan and places the fan on the side. She presses the on/off button and removes the cooling layer from the cooling unit. She places them on the side.
06:38		Turn off.	L3 presses the on/off button on the app and changes the screen.
06:49		Make everything settle down.	L3 makes sure all the prototype elements are in place.
06:53	I	Okay, cool. Thank you very much.	
06:55	L3	You're welcome.	
06:57	I	Yeah, and so now to the next part. How usable did you find the system, and do you have any suggestions on how it could be made better?	
07:15	L3	Maybe you can set another variable, maybe, like, if the direction makes any sense, from	L3 first indicates different positions to her left, front, right

TC	ID	Conversation	Gestures
		this direction or this direction, or how big the office is.	and in reverse order. Then she points out air coming from her left and air coming from her right.
07:29		Is it an office that's shared with other people, or is it just my own office, because sometimes I will think about if I turn on or turn off the temperature, it is for the whole temperature for the office.	
07:45		So, I might influence other people, and I may just use this little device, or this one, to make myself colder or hotter.	L3 picks up the fan and places it in front of her and briefly reaches out for the cloth.
07:54		As for the whole average temperature, if I don't go on to influence other people, and they do not use the app or something to turn... I may just use this device, to more direct to myself, I guess.	L3 briefly points towards the app. She then picks up the fan with both her hands holding in front of her. She indicates towards herself with her right hand and then puts down the fan.
08:13	I	Yes. Okay, but the way you used it, was it okay?	
08:21	L3	Yes. I feel good to use this.	
08:25	I	You liked it?	
08:26	L3	Yeah, I like it.	
08:27	I	Okay, thank you very much. This is already it. So, I'm going to switch off the video camera, and I just have a questionnaire for you to fill out.	
08:39	L3	Okay.	

Participant L4

TC	ID	Conversation	Gestures
00:01	I	Okay, so I'm going to give you this scenario. It is a cold September day and you are working in your office and the space heating has not been switched on yet. You have been sitting at your desk for a while already and are starting to feel chilly. You have been given this personal heating and cooling device. Please talk us through how you would use it.	
00:33	L4	Um [pause] Well, I think I would turn it on to 'hot' [pause] and, I quite like the device itself rather than ... rather than the app.	L4 pick up the control unit and places the heating layer inside.
00:52		I quite like the physicality of it, so I can turn that on. And [pause], I'd start it off maybe halfway-ish and see how it goes.	L4 turns the control unit to the camera and presses the on/off button. She turns the dial half-way.
01:06		And, since it's a cold day I would probably use something like a cloth because I quite like being wrapped up. So, I might wear it as a scarf or something like that.	L4 picks up the cloth and wraps it around her neck.

TC	ID	Conversation	Gestures
01:17		And then attach it to there. And then it could like warm me.	L4 picks up the control unit and places it at one end of the scarf so it sits on her left upper body.
01:21		If it's really cold, I would probably have it over my shoulders and stuff. That would be cosy. Yeah.	L4 puts the control unit back on the table and wraps the cloth around her shoulders. She picks up the control unit and places it on the cloth, slightly to the right of her left shoulder on her upper body.
01:28	I	Okay.	
01:30	L4	Is that alright?	L4 removes the control unit and places it on the table.
01:31	I	Yes. So ... and after a while the temperature you originally set starts feeling ... you are still a bit too cold with it and you want to adjust it. So please do so.	L4 removes the cloth and puts it on the table.
01:45	L4	Okay. So I put this back on. We are doing a role play.	L4 picks up the cloth again and puts it around her shoulders. She picks up the control unit and places it back on her upper body.
01:52		And then I turn it on. Turn it around to warmer. [pause] Perhaps if I was in a hurry or something like that, I might use the app, but I like playing with it physically.	L4 presses the on/off switch on the control unit and starts turning the dial. She removes the control unit to adjust the setting. She places the control unit back on her body.
02:13		I mean, if there is a little, like, something on the desktop. Like if I could carry on working, that would be interesting. Yeah.	L4 indicates a small rectangle in mid-air with her right index finger and thumb. She indicates clicking with her right index finger and makes a clicking sound, then imitates typing with both hands.
02:22	I	Okay. So, now it's time for your lunch break. You are planning to leave the office. What would you do with the device?	
02:35	L4	Well, if I am at a comfortable temperature, I would probably keep it and take it with me. See how it goes.	L4 folds her arms.
02:42	I	Okay. Great. Okay, so [pause] yeah [pause] it's the [pause] so you are back in your office. You have been working there for a while, and it's now end of your working day. And you are getting ready to go home. So, what would you do with the device?	
03:12	L4	Mmm. Well it could be useful wherever you are, couldn't it? I think I'd be slightly conscious of the energy consumption of wearing something like this permanently. But perhaps it would be something I would only use at work occasionally. And where I couldn't get a blanket or cosy. So, I would probably turn it off, and leave it at work	L4 removes the control unit from the cloth and adjusts the setting. She presses the on/off switch on the control unit and removes the heating layer. L4 puts the control unit on the desk and removes the cloth from her shoulders.

TC	ID	Conversation	Gestures
		although I would be tempted to take it home if I was very comfy.	
03:49		[mutual chuckles]	
03:51	I	Okay. Thank you. Do you have time for another scenario?	
03:58	L4	Yes, sure.	
04:00	I	So [pause] when it's a warm day outside and the sun is heating up your office, opening the windows doesn't provide relief. You been again given the heating and cooling device. Please talk us through how you would use it.	
04:28	L4	[Long pause]. I think because, for the novelty of it, I would like to try this with the cooling. But I suspect that it would be nice to have a cool breeze. So, would I use both?	L4 points toward the cloth. She reaches for the cooling layer and places it in the control unit.
04:44		I could try both and then, well I could have that on without a device on it turning it on. And have the cooling shawl [long pause]. Like that ... yeah.	L4 reaches for the fan. She then adjusts the control unit setting to about 5 o'clock and places it on the cloth.
05:05	I	Okay.	
05:07	L4	Probably. I would probably try the shawl again.	L4 rearranges the control unit on the cloth.
05:09	I	Okay. So you would put it ...	
05:12	L4	Sorry. Well, I'd were the shawl. Yeah.	L4 indicates wrapping a shawl around her shoulders.
05:15	I	Okay.	
05:15	L4	And have that on there. And then, yeah, see how that goes.	L4 places the control unit next to her left shoulder.
05:23	I	Okay. [pause] Okay, so [pause] you are again going for a lunch break, and you're planning to leave the office to go to lunch. So what would you do with your device?	L4 puts the control unit back on the cloth.
05:54	L4	[Pause] Well it might depend on how hot it is outside, or in the rest of the building. [Pause] But I think I would probably, in that case I would probably just [pause] turn it off and leave it in the office, because it would be more ... a bit more ... kind of bulky. I would probably just wear a T-shirt ... prefer to wear a T-shirt out. I would have thought, rather than carrying it around.	L4 picks up the control unit and presses the on/off button.
06:25	I	Okay.	
06:26	L4	You don't need the same kind of cosiness as when it's cold.	L4 imitates wrapping something around herself.
06:31	I	Okay. Thank you.	
06:34	L4	Okay.	
06:35	I	And so, those were already the scenarios.	
06:37	L4	Uh-huh.	
06:38	I	And, so how usable and useful do you think the device was, and do you have any suggestions for alterations?	

TC	ID	Conversation	Gestures
06:50	L4	Ah, the only thing maybe that I could suggest is an app on a desktop because if you're working and you've got to find your phone with the app or fiddle around with something where you are ... it could be just a little bit more accessible [pause] but I really like the idea of something wearable that changes temperature [pause]. But I guess [pause] Yeah, I would hope that it was quite energy-efficient.	L4 imitates looking for and using a phone. She then hovers her hand close to her left shoulder imitating the adjustment of the control unit she placed there earlier.
07:35		[Mutual chuckling]	
07:39	L4	It could be nice to sort of experiment with other types of garments, or something a little bit more ... more personal, like on your person, than a fan because that affects other people as well. Or can make a noise and things like that, because it's distracting.	L4 picks up the fan prototype. She holds it in her hand while gesturing. Then she puts it back on the desk.
08:01		But the fan's good as well ... feeling like you're moving the air around you. I think it would depend. I'm more likely to use the fan if it's hot and stuffy.	L4 points towards the fan.
08:12	I	Yeah.	
08:13	L4	And I'm more likely to use that if it's cold.	L4 points towards the cloth.
08:15	I	Okay.	
08:16	L4	And I want to feel cosy.	
08:19	I	Okay. Well, thank you so much.	
08:21	L4	That's okay.	
08:22	I	So, yeah, now I have the questionnaire, but we are done with the recording.	
08:27	L4	Okay.	

Participant L5

TC	ID	Conversation	Gestures
00:01	I	So, it's this scenario. It's a regular office day, and you've just come into the office from outside, and you feel slightly hot from walking in the cold, and you've come now to a warm office. You've been given this personal heating/cooling device to use, and please talk us through how you would use it in that case.	
00:23	L5	This or this?	L5 points towards the fan and then towards the cloth.
00:25	I	It's up to you, it's your choice.	
00:28	L5	Okay. So, I guess I'll go for that one in this case.	L5 points towards the fan.
00:37		So, I think I'm going to do it from my phone. Open the app and turn it on, and put the slider into there,	L5 briefly picks up the control unit, then puts it back and picks up the phone. She holds it in her right hand.

TC	ID	Conversation	Gestures
00:56		cooling, yeah, and place this somewhere that it's going to go to my face, yeah. That's all, I think.	The interviewer hands L5 the app view for cooling. L5 takes it and then moves the fan at 10 o'clock, facing her left side. She indicates air blowing towards her face.
01:09	I	Okay, that's fine.	
01:12	L5	Okay. Do you need more details?	
01:15	I	No, it's fine. Okay, and so after a while, your body has cooled down, and you're now feeling a bit chilly. So, what would you do?	
01:37	L5	So, turning this off, and I guess I'm going to use this now.	L5 indicates towards the fan and presses the on/off switch on the app. She is then pointing towards the cloth. She puts down the app.
01:48		So, I think I'll put this around my body. I do this quite often to my office, because I have a blanket there. So, yeah, I guess I'll put it like this and, again, use the app, turn it on and put it to there.	L5 indicates wrapping a shawl around her shoulders. The interviewer indicates towards the cloth. L5 picks it up and opens it. Then she puts it around her shoulders. She picks up the app prototype and switches it on. She indicates moving the slider up.
02:11		Not... It depends how much I'm going to feel cold, but put the heating upwards, so yeah. So, I'm going to put it further up, yeah.	The interviewer hands L5 the app screen for heating. L5 puts it on the phone prototype and moves the slider all the way up.
02:27	I	Okay, that's fine, and now it's time for your lunchbreak, and you're planning to leave the office for your lunch. So, what would you do with the device?	L5 puts the app down.
02:48	L5	I mean, it depends, because, sometimes, for example, with the radiator, because we've got an electric radiator there, I can leave it on because I need to come back, and I need the place to be warm enough for me to continue working.	L5 indicates a radiator towards her right.
03:02		So, if I go for a half an hour break, maybe I can leave... and it depends how long a time this needs to warm up. So, maybe I will leave it on and go. I don't know how safe it is, but yeah.	L5 indicates and touches the cloth around her shoulders.
03:18	I	It's supposed to be safe.	
03:20	L5	And come back to put it on again.	L5 holds the cloth around her shoulders with each hand holding its edges.
03:23	I	Okay. So, now, basically, you've been to lunch, your lunchbreak, and you're back in your office. You've been working all day, and now it's time to go home. So, you're ready to go, and what would you do with the device?	
03:45	L5	Turn it off. Leave it on my chair, I guess, and go, yeah.	L5 points towards the app.

TC	ID	Conversation	Gestures
03:52	I	Okay, so could you please turn it off for me?	
03:55	L5	Just pressing this, yeah.	L5 picks up the app prototype and presses the on/off button on the app.
04:00	I	Yes. No, that's fine. Okay, that's fine. That's great.	L5 removes the cloth from her shoulders.
04:07	L5	If you need more details, tell me. I mean, I don't know if, maybe, I'm jumping some steps or anything, which I cannot think.	
04:19	I	No, that's fine. I mean, don't worry. I mean, that's perfect.	
04:23	L5	Okay, good.	
04:26	I	Yes. Well, thank you for this. How useable and how useful did you find the device, and do you have any suggestions for alterations?	
04:57	L5	I mean, I'm just thinking about this, if it can be something that you can put on your chair, or like a blanket that you've got on the bed and it warms up, or something like this.	L5 touches the cloth with her right hand. She rubs her hands briefly and then puts them with the palms up in mid-air, slightly moving them up and down.
05:14		Because if you have it like this, maybe you will feel very warm here,	L5 indicates wrapping it around her shoulders. She briefly touches her upper arms.
05:20		and, yeah, you can say that if you have it under the chair you can... I don't know.	L5 briefly turns around on the chair and touches its seat.
05:28		But, yeah, I think if it's going to be something you can sit on and the heating is coming up, maybe it will be nice, yeah.	L5 briefly moves up out of the chair and sits back down. Then she moves her hands, palms facing up, briefly in front of her body.
05:38	I	Okay, yeah. Could you just use this and show me what you...?	The interviewer points towards the cloth.
05:46	L5	Yeah. So that you can have all around the chair like this.	L5 picks up the cloth and opens it up. She gets up and spreads the cloth over the chair's back and seat.
05:58		I mean, you will use the same controller, and you can say it, and it can give you air like this or like this, all around the body, yeah.	L5 sits back down on the chair. She moves her hands up and down next to her body and then from the back to the front.
06:10	I	Okay. So, you would prefer air, or more like the surface heat or cold?	
06:19	L5	Maybe, for the heating, surface to be hot, and for the cold, air that comes, yeah, all around me, I guess. I'm just saying.	L5 spreads her hands in mid-air. Then she indicates air flowing from the back.
06:33	I	Yeah, I know. That's fine. Okay, that sounds good. Okay. So, you would leave it on the chair, or it would be part of the chair?	
06:46	L5	It can be something that you can have, like elastic things that you can put like this on the chair, or you can wear it like a seat on the chair.	L5 stands up and stands next to the chair. She indicates pulling

TC	ID	Conversation	Gestures
			an elastic strap over the edges of the chair.
07:00		Or, I don't know, something that you can adjust it depending on... it will be suitable for different chairs, yeah. I guess, you're more interested for office, office chairs?	
07:12	I	Yeah. Well, I'm looking at offices because, usually, you share the space with people.	L5 sits back down.
07:21	L5	But I would love to have one that I can have on my chair and feel warm, yeah. We've got many disagreements in the office about the temperature and everything, and I always have a blanket at my feet, so yeah.	L5 indicates wrapping a blanket around her feet.
07:36	I	Okay, yeah. Thank you so much. That's all I need. Yeah, that's it already. So, I'm going to switch off the video camera.	

Participant L6

TC	ID	Conversation	Gestures
00:01	I	Okay, so this is the scenario. It's a cold September day, you're working in your office, but the space heating has not been switched on yet. You have been sitting at your desk for a while already, and are starting to feel chilly, and you have been given this personal heating/cooling device to use. Please talk us through how you would use it, and if you would use it.	
00:26	L6	Okay. So, I guess I'd use it because I'm cold. This thing's on the fan. Okay, I'm imagining the fan's, like, on the desk over there, I guess.	L6 picks up the fan and places it at arm length to his left, at about 10 o'clock.
00:39		So, this thing's attached to it. So, it's cold. So, let's turn it on. So, let's try it on to that there. So, yeah, sure, now it's hot.	L6 picks up the control unit and puts it on the fan. He changes the dial position on the control unit. The interviewer adds the heating layer.
01:15		And if the fan's there, I don't really need to use this, because I can just, like, do this.	L5 briefly points towards the fan and then picks up the app and places it back down on the desk. He makes a turning movement with his hands.
01:21		Unless this is telling me what temperature it is, but, again, I don't really need that. If this was up on the wall or something, then, yeah, I can control it from here.	L5 picks up the app again and looks at the interface. He then puts it back on the table. He briefly points up to the wall and then points towards the app.
01:30	I	So, it's personal. So, you could also put it anywhere you like.	
01:40	L6	Okay, cool. And then... So, this thing goes somewhere here. So, let's try that.	L6 briefly picks up the fan and moves it in his hand. Then he

TC	ID	Conversation	Gestures
			puts it back down and picks up one cloth placing it over his upper legs and another one wrapping it around his shoulders. He places the control unit on his left upper arm but then readjusts trying out different positions on his left upper arm, shoulder and upper body.
02:25		Let's put it on there, and there's something quite nice about wrapping yourself in something. So, maybe that's good. So, yeah, shoulders and, like, knees and legs might be a good place to keep warm.	L6 puts the control unit on top of his left shoulder. He wraps the cloth a bit closer around his shoulders.
02:46		And, again, if it's, like, in reach, then... but now it's in quite a weird place to touch. So, maybe that app is useful now.	L6 reaches for the control unit on his shoulder. He picks up the app instead.
02:59	I	Okay. How would you put it to heat or cool?	
03:04	L6	I don't know. I guess it would be hot because it's supposed to be cold, but it would be hard to tell unless I'm in the scenario, like, for real.	L6 looks at the scenario description.
03:18		But yeah, I guess I'd make it warmer, because it's meant to be a cold day. Yeah, I suppose things to consider is, like, how grain this works because the thing I'm thinking of is, like, when you're in the shower and you're turning the tap, sometimes you just turn it a little bit and it gets really hot. Or you can just turn the cold a little bit, and, all of a sudden, you're really cold. So, how those things are calibrated, I suppose, is quite important.	L6 touches the app screen.
03:50		I mean, I'm not totally sure how I feel about having this, like, parrot on my shoulder, which is making me warmer. It's a bit weird, but I guess that's okay.	L6 touches the control unit on top of this shoulder.
04:07		Yeah, I used to teach in a school in Japan, and that was always super cold. They always had the windows open in the winter, and the kids had these little heat packs that they'd snap, and then put on their bodies until they got cold. It's a chemical reaction, just heated them up, or they'd put them inside their gloves, which was quite good, and they weren't allowed to wear scarves in the lesson, which they always complained about, but yeah, put this around here.	L6 indicates snapping a heat pack in mid-air and putting it on the upper legs. He rubs his hands together slightly.
04:39		Yeah, I think it's better on the body than on here. I mean, here's okay, but then all the heat's coming up everywhere. It's personal preference as well. I don't mind the air around me being cold if I'm warm. So, probably the first thing I'd do is probably, like, try and warm my body.	L6 removes the control unit from his shoulder and puts it on the fan. He leaves it for a short time then picks it up again and places it back on his shoulder.

TC	ID	Conversation	Gestures
05:06	I	Okay, cool, and now it's time for your lunchbreak, and you're planning to go out for lunch. So, what would you do with the device?	L6 wraps the cloth close around his body.
05:14	L6	Can I take it with me? Okay. Probably, just take this bit off my legs, and with this, kind of, robot heating parrot on me, I'd get up, go out and get lunch, and then come back.	L6 removes the cloth from his legs. He gets up from the chair, walks around and sits back down.
05:37	I	Okay, cool, and now it's the end of your working day, and you're getting ready to go home. So, what would you do with the device?	
05:50	L6	Now it feels like it's part of this whole cloth. So, I'd probably take the cloth off, just, like, put it on the back of the chair, yeah. Leave this on the table and go away.	L6 removes the cloth around his shoulders. He puts it over the back of the chair. He puts the control unit on the table.
06:10	I	Okay. Can you please switch it off?	
06:12	L6	Oh yeah, sure. I forgot. Okay, cool.	L6 removes the heating layer from the control unit.
06:30	I	Okay, thank you. This was great, and how useable and useful did you find it, and do you have any suggestions?	
06:40	L6	I mean, this is all quite abstract because I'm not very cold, but I like it over the shoulders. I think that's good. I like it on the body, in which case, maybe the app control is better, because this is very fiddly.	L6 leans back in his chair. He imitates wrapping something around his shoulders. He briefly touches his shoulder, where the control unit was.
07:10		On here, the app control is not really something that I'd worry about, because you can just reach out and do this. But, yeah, I like it as a wearable thing.	L6 touches the fan.
07:24	I	Okay, cool.	
07:29	L6	Is there another question?	
07:33	I	No, I think you explained it very well. So, there's nothing in specific that you'd like to have changed? I mean, this is a cloth. Would you have preferred it to be some garment?	
07:55	L6	No, I like the blanket. It's nice as a blanket, yeah. I mean, maybe it's a little inconvenient to work with, if you're doing this, like it's falling off your shoulders, but you could put a safety pin on it or something. Then it's quite nice.	L6 indicates wrapping it around his shoulders. He imitates writing on a keyboard. He briefly points towards his mid-chest.
08:09		Yeah, but I mean this is, kind of, like, a fashion choice, or whatever, but a nice textured blanket. Like a nice material, that feels nice against the skin, and doesn't feel like polyester, then, yeah, that'll be good.	
08:20	I	Okay, cool. Okay, thank you very much.	

Participant L7

TC	ID	Conversation	Gestures
00:01	I	The scenario that I have is the following: so, it's a regular office day, you've just come into the office from outside. You feel slightly hot from walking in the cold and coming into the warm office. You've been given this personal heating/cooling device to use, and please talk us through how you would use it.	
00:25	L7	Okay, I can imagine this scenario – pretty well. So, yes, when I come in and feel slightly hot and slightly sweat, I think I would go for the ventilator.	L7 gestures slightly in front of her face and then touches the fan prototype with her left hand.
00:43		So, I think you have to take it and attach it to the ventilator and then turn it on. And then, oh yeah, to cool it, shall I?	L7 reaches for the control unit. She picks up the fan and attaches the control unit to it. She holds the fan in her left hand and presses the on/off button on the control unit with her right hand. She picks up the cooling layer and tries to place it in the control unit.
01:01	I	Yes.	L7 puts the fan prototype on the desk to attach the cooling layer. Then she puts it pack up at about 45 degrees to her left side.
01:15	L7	Switch it to cooling and then... Sorry. Then turn it on but not too cool because it's cold. It's still a cold day, so turn it on and get a bit of cool air to calm down from walking and being exhausted. Yes, feels good, feels good.	L7 turns the dial of the control unit on the fan. She turns it to about 20%. She turns the fan on the table, so the dial faces towards the camera and the fan blades towards her. L7 simulates air flowing towards her and then continues gesticulating.
01:52	I	Okay.	
01:52	L7	Yes.	
01:53	I	Okay so after a while, your body has cooled down and you start feeling a little bit too cold with the ventilation. So, what would you do?	
02:10	L7	Okay so, first, yeah, if it's getting a little bit cold I turn it off, or I maybe turn it a little bit lower first. So, still warming but a bit lower.	L7 reaches for the fan prototype on the desk, turns it so she can reach the control unit and starts turning the dial. She puts it to 10% and turns the fan back, so it faces her.
02:25		It's still maybe too cold, just imagine it's still too cold, okay. I just turn it off.	L7 reaches for the fan prototype and indicates switching it off.
02:34	I	Alright, okay. Yeah, that's fine. So now it's time for your lunch break and, yeah, what would you do with the device? You're planning to go out to have lunch, so you want to leave the office.	

TC	ID	Conversation	Gestures
02:50	L7	Oh, and it's still a cold day? Maybe, yeah, my jacket is not so warm today. Should I take it with me? I think it's a good idea. Let's remove the cold because I turned it off.	L7 picks up the fan prototype. She removes the cooling layer. Then she removes the control unit from the fan prototype. She places the fan back on the table.
03:18		That's it, I'll take it with me. I just have my little bag, I put it in my handbag - it's small. I take it with me and I go.	L7 holds the control unit in her left hand and indicates putting it into her handbag hanging from her left shoulder by moving it down her left side. She puts it back on the table and simulates getting up and walking out.
03:28	I	Okay, that's perfect.	
03:30	L7	Okay.	
03:31	I	Okay, so yeah, that was the first scenario. And I have another one we could play through. So, this one - it's a cold September day and you're working in your office, but the space heating has not been switched on yet. You have been sitting at your desk for a while already and are starting to feel it's chilly. You've been given this personal heating device to use and please talk us through how you would use it.	The interviewer changes the scenario text in front of the participant.
04:08	L7	Okay, I can also relate to that one. Okay, it's getting cold, I already have my jacket on. That's the thing, I don't know... I comment here. I don't know because I've not experienced it, maybe I would use it with the fan again because getting a bit of warm air feels comfortable to me. So, I sometimes do that at home with my baking oven. So, I turn it on and then make it open a bit and get the warm air.	L7 wraps the jacket she is wearing closer around her. She briefly touches the fan prototype on the table and indicates air flow towards her upper body.
04:49		But should I try with the clothing because that's also, if you have a nice...? Okay, I try clothing today. So, I have this - can I imagine it's a jacket?	L7 picks up the cloth and puts it on her lap first then opens it up and holds it in front of her.
05:06	I	Sure.	
05:07	L7	Okay. I have this nice jacket, I put it on. I imagine I already wore the jacket - okay. So that's my jacket I've brought today.	L7 puts the cloth around her shoulders.
05:28		I turn on my device. I feel quite cold, quite cold. Okay.	L7 picks up the control unit. She puts the heating layer in and turns the dial to around 35%. She tries to attach it to the cloth around her shoulders, but it falls onto the table. She presses it again on the cloth next to her left shoulder until it sticks.
05:57	I	Okay, so after a while, the temperature you originally set starts feeling too cold and you want to adjust it, so please do so.	
06:15	L7	Okay, I still feel cold. There's still a bit of room to get a bit warmer. Okay, so.	L7 removes the control unit from the cloth and turns the dial up to about 65-70%. She tries to attach

TC	ID	Conversation	Gestures
			the unit back onto the cloth, but it slides down again. She tries again until it sticks next to her left shoulder.
06:39	I	Okay, thank you. So now it's the end of your working day and it's time to go home and you're getting ready to go home. So, what would you do with the device?	
06:54	L7	Oh. Okay so it's, I'm going home so I turn it off because now I'm walking again outside so I might get warm from walking. So, I don't need heating maybe because it's just September.	L7 removes the control unit from the cloth and then removes the heating layer from the unit. She readjusts the layers of the control unit.
07:19		Okay, but since it's nice and tiny, I can just put it in my bag and take it with me. So, I take it with me.	L7 holds the control unit up in front of her. Holding it in her right hand she moves it down her left side imitating how to put in a hand bag.
07:29	I	Okay, great. Okay, thank you very much. So, this was the scenario bit and so how usable and how useful did you find the device? And do you have any suggestions, any alterations that you think it needs, for you, to be useable?	L7 puts the control unit back on the table.
07:57	L7	First thing, if it's really looking like this and maybe just this thick and if it's really light, I would definitely consider it, really useable and also mobile usable. So, if I'm on the go and feel it's getting colder, I just can attach it and turn it on. So, the form factor is quite nice, I think, if I imagine it like this.	L7 picks up the control unit and holds it into the camera. She indicates a thickness of about 3 to 4 cm.
08:24		The other thing I really like is this spiral thing, which looks really nice. So that's...	L7 puts the control unit on the table and runs her left index finger along the dial.
08:38		I just saw the mobile phone and thought, 'Okay.' In one scenario I could have done it a bit differently without detaching it and changing it because I think that's what the app is for and if I have attached it somewhere, I can use the app to change it - but I didn't do that.	L7 points towards the app prototype. She replays detaching the control unit from her upper body, close to her left shoulder.
08:55	I	Yeah, well it's up to you, you can make it so... you can do both. So-	L7 picks up the control unit.
09:00		Yeah, so it wasn't really hard to just detach it, just change it and put it back on. So, yeah. I could quickly do that without looking for my phone and finding my phone. So, I find the concept really easy and simple to use.	L7 holds the control unit briefly onto the cloth over her shoulders. She indicates changing the settings and holds it back onto the cloth.
09:17		And, yeah, if I just imagine I have two buttons - just hot and cold, and then I can adjust how hot or cold it should get. It's really, really easy. I like that.	L7 runs her finger around the dial on the control unit in her hand.
09:29		And I also like this thing that you have two different kinds of getting cold or hot - hotness -	L7 briefly points towards the fan prototype and continues moving her hand to and fro between the

TC	ID	Conversation	Gestures
		through air or through contact, which was really nice.	fan and the control unit. Then she points once from the fan to the cloth around her shoulders.
09:42		Because, yeah, sometimes you might want to have a little breeze. But sometimes it's just not comfortable so it's good to just attach it somewhere. So that's what I found really nice.	L7 fans air towards her face.
09:58		Yeah, also that it's just, you can just detach it, attach it so it's really, really easy.	L7 moves her left hand to and fro between the cooling unit on the desk and the fan as well as the cloth.
10:07	I	Yeah.	
10:13	L7	This is also concerning the colours of the device. So, if I imagine this device is white, that would be alright. So-	L7 picks up the control unit and runs with her finger once around the dial before she puts it back down again.
10:23	I	Okay.	
10:24	L7	Yeah, because it looks clean and usually I like white devices like with a glossy finish or something because they look clean and professional. So, I would like that if it's white.	L7 gestures with her hands
10:40		And I also like the dots, that it's just, yeah, a light changing when it's hot or cold so it's really easy and really something.	L7 briefly hovers with her hands over the control unit and the heating and cooling layers on the desk.
10:52	I	Okay, thank you so much.	

Participant L8

TC	ID	Conversation	Gestures
00:01	I	The scenario is this one. It is a warm day outside, and the sun is heating up your office. Opening a window doesn't provide relief. You have been given this personal cooling device to use. Please talk us through how you would use it.	
00:24	L8	So, I can choose this. I think... 'it's a warm day outside'...	L8 picks up the control unit with her right hand as well as the app prototype with her left. She weighs both up and down while considering.
00:32		Yeah, the fan, maybe. Yeah, okay. Do I just talk now how would I use it?	L8 drops the app and picks up the fan prototype with her left hand instead. She puts the control unit on the fan.
00:44	I	Yeah, what are you doing and...?	L8 detaches and attaches the control unit from the fan.
00:47	L8	Imagine I'm in the office. Sorry, do I need to attach this to my body, personal cooling, or just putting it aside?	L8 holds the fan prototype in her left hand and moves it first briefly towards her upper body and then away from it.

TC	ID	Conversation	Gestures
00:56	I	Yeah, you can put it anywhere you would like. It could be on your desk.	
01:02	L8	Yeah. If the fan is big enough, maybe I would like to ask other colleagues if they want to share it, so we can all feel more relieved from the hot weather.	L8 continues holding the fan while she is slightly gesturing.
01:16		If it's a small fan, I think either put it on my desk, facing my body, because I will usually feel more hot on my upper part of the body, especially when I'm working on something. I'm constantly moving.	L8 puts the fan prototype on the desk in front of her, at about arm's length. She moves her hands and arms while slightly hovering over the desk surface.
01:35		If I'm sitting in the office, I won't feel that hot on my lower body, because it's constant that they'll move.	L8 moves her hands from her hip down.
01:43		Yeah, I would prefer it to give me colder winds, just cooler than the current temperature. Just a room temperature, the wind. I will feel more comfortable. So, like an air conditioner, but not too cold, otherwise I think I might easily get cold in the summer.	L8 picks up the fan prototype with her left hand and indicates towards her upper body with her right hand. She puts the fan back down only to pick it briefly back up again and put it back down.
02:10		And also, I think for the sake of saving energy, I don't want it to be on all the time, and the air should be turned on, off, on, off. Just, yeah, automatically, I don't have to do this by myself.	L8 gestures with her hands.
02:31		I would've preferred to use the smartphone to adjust the temperature. If it's close to me enough, I will just dial the wheel to change the temperature.	L8 picks up the app prototype. She puts it back down and reaches for the fan. She holds it with her left hand and runs her right index finger around the dial or the control unit.
02:45		If, say, I will move around in the office, I can use the smartphone to change the temperature, yeah, and I want the device to help me maintain the temperature around my seating area.	L8 picks up the app prototype. She moves her arms circling around her upper body.
03:01	I	Okay, that's cool. Okay, thank you, and can you set the device temperature to a setting you think would be good?	
03:14	L8	Set this to...?	
03:16	I	Yeah.	L8 picks up the cooling layer.
03:18	L8	Okay. So, if it's a warm day, but not very hot, I think probably here.	L8 puts the cooling layer into the control unit and moves the dial up to around 80%.
03:32	I	Okay, thank you. Okay, so, I mean, you already said you would adjust it, or you would want it to switch on and off, probably. But so, let's imagine that the device is providing too much cooling now, and you start feeling a bit too cold, and a bit chilly. So, what would you...?	L8 holds the fan prototype up with the dial facing the camera. She then puts the fan back on the table.
04:06	L8	I will turn it off for now, and keep working on my work, and then when I feel hot again, I will turn it on, but maybe to here.	L8 picks up the fan prototype and turns the dial of the control unit to zero. She puts the fan on the table briefly, but then picks it

TC	ID	Conversation	Gestures
			up again. She turns the dial to 7 o'clock.
04:26	I	Okay, that's fine.	L8 puts the fan on the table, control unit facing up.
04:29	L8	I hope it can work on and off again, not constantly blowing wind to my body.	L8 indicates wind blowing towards her with both hands.
04:36	I	Okay, thank you.	
04:38	L8	And I would like the wind to blow to my body when it's on, because I think it's more effective. I want the instant feedback, and faster effect. When I feel hot, I want to be suddenly cool.	L8 slightly holds and tilts the fan on the table before letting it go again. She moves both her hands up towards her face.
04:54	I	Okay, cool. Yeah, so now it's time for your lunchbreak, and you're planning to go out for lunch. So, what would you do with the device?	
05:06	L8	I think I will just press to close. It's like the way that I'm talking to someone, or I was just planning to pour some water, then suddenly decided to go to lunch with my colleague, then I might forgot to turn it off.	L8 presses the on/off switch on the control unit.
05:23		So, it would be nice I can turn it off from my phone, but I think that the phone should indicate to me that the device is still on. So, maybe there should be a Bluetooth connection.	L8 picks up the app prototype and holds it in her left hand. She moves it slightly to and fro towards the fan.
05:39		So, if I'm far enough from the device, it should tell me that I've lost a connection with my cooling device. I think if it can also be turned off automatically or I can be sent an alarm saying, "You are leaving your office, but your cooling device is still on," so I can turn it off.	L8 leans back briefly. She continues gesturing slightly and, in the end, presses the on/off button on the app.
05:59	I	Yeah, okay. Thank you. That's very interesting, actually. So, yeah, we're actually done with this scenario. I don't know, do you have time? Do you want to do another one?	L8 puts down the app prototype onto the table.
06:16	L8	Yeah.	
06:18	I	Okay, let's do this one. It is a regular office day, and you have just come into the office from outside, and you feel slightly hot from walking in the cold and coming into the warm office. You've been given this personal heating/cooling device to use. Please talk us through how you would use it in this scenario.	The interviewer exchanges the scenario description in front of L8.
06:51	L8	I think I will... So, if I'm outside to a warm office, obviously, I feel hot from walking in the cold. Come to the warm office. How exactly would I feel? So, I feel hot. I would take off my jacket first, then if I feel still hot because I was kept walking, I will turn it on, but I wish, in this case, it can be on all the time.	L8 briefly reaches for the control unit on top of the fan prototype. Then she takes a closer look at the scenario. She enacts taking off a jacket and then a walking movement. She points towards the fan prototype.
07:28		In the warm, I feel the temperature's about right, I just want to turn it off, and I think I won't dial the controller to a very strong wind, because I	L8 makes a closing down movement with her hand. She turns the dial on the control unit. She holds the fan with the

TC	ID	Conversation	Gestures
		know that I will easily get colder in this case. So, maybe, just here, yeah,	control unit into the camera. The dial is set to the beginning of the temperature wheel.
07:51		and the colder wind to help me cool down, but then I think once I feel comfortable, I will just switch it off.	L8 puts down the fan onto the table. She lifts her hands up and then moves them down. She then briefly moves her left and towards the fan.
07:58	I	Okay. So...	
08:02	L8	Sorry, I need to add another bit. So, in this case, I would prefer it's my personal device; it's on my desk, or close to my desk.	L8 picks up the fan with her left hand. She hovers it over the table surface at about arm's length and then slightly higher up.
08:14		So, why can't we put it on the back of the chair? It will feel nice too, so it won't affect anyone else. It's just for my personal use, and I hope, in this case, the controller can be easily reached.	L8 holds the fan against the back of the chair while facing forward. She brings the fan back to the front.
08:34		I think I open my smartphone and open the app to turn it on will take too much effort. I would prefer there is a physical controller I can easily reach, say a button – pow! – or it is on my chair, the side of the chair. I can just push it to change the state.	L8 points towards her smartphone on the table and then towards the app prototype. She briefly reaches towards her right to indicate controlling something, then towards her left, moving her hand down to indicate pressing a button. L8 then reaches towards the side of her chair. She then puts down the fan she was holding.
08:55	I	Okay, cool. So, we're going further in the scenario. So, yeah, after a while, you've cooled down and, because you've been sitting for a while, you're starting to feel cold. What would you do? Will you change?	
09:18	L8	I will open some warm wind and then not too much, because I don't like feeling too hot in the office. It makes me feel sleepy during the day.	L8 puts the heating layer into the control unit of the fan prototype and sets the dial to about 3 o'clock.
09:33		So, maybe just slightly help me warm up the environment slightly with just a little wind, not too strong. Also, I would prefer to use a physical controller in this way.	L8 picks up the fan prototype and adjusts the dial setting slightly. She shakes the fan prototype slightly and puts it back down.
09:52		If I'm away, I would use a mobile device to control the temperature, but if I'm here with the actual device, I would prefer to use a physical controller.	L8 picks up the app prototype and enacts adjusting settings on it. She puts it back down and points towards the fan. She briefly picks the fan up and puts it back down.
10:06	I	Okay, cool. Thank you. So, now it's the end of your working day. You're getting ready to go home. So, what would you do with the device?	

TC	ID	Conversation	Gestures
10:20	L8	I think if it doesn't blow a strong wind out of the fan, it's very likely I will forget to turn it off when I leave the office.	L8 moves her left hand towards her face. Then she picks up the fan prototype and holds it with her left hand.
10:32		In this case, I think if I remember, I will turn it off from my mobile phone. If I forgot, then I just forgot. I hope it can be disconnected. So, say if it's mounted on my chair and the system detected that I'm away from the chair for a long while, it can be automatically turned off. If it doesn't, then I think it's very likely to happen, yeah.	L8 puts down the fan prototype. She picks up the app prototype and holds it in her left hand while gesturing. She eventually puts it down.
11:03	I	Okay. Well, thank you so much for this. We're done with the scenarios. So, how useful and how useable did you find the device, and do you have any suggestions, like any alterations that you'd like to see?	
11:21	L8	Yeah, I think the device, I pictured it in my mind, and might be different from maybe someone else had in their mind. I think if a device can be easily reached and is very effective to help me, just to warm me up and help me cool down, I think I will enjoy using it.	L8 briefly reaches out and touches the fan prototype on the desk. She then briefly puts her arms close to her upper body as if to wrap herself and then lowers both her hands in front of her body.
11:51		It can be an important part of my daily life in work, because it'll make me feel more comfortable. Sometimes... Yeah, I hope... the feedback is based on my mind of this.	L8 reaches for the fan prototype on the desk and puts her hand on top of it. She lets go. L8 picks up the fan prototype.
12:18		So, I hope this thing is not... I think the absence of this cooling device should be hidden as much as possible, just not a big fan on my desk.	L8 indicates a rectangle in mid-air while still holding the prototype. She briefly pauses. She hovers the fan over the desk at arm's length.
12:34		It doesn't look good, and maybe dust will go in after a while, and it's taking my working space. So, I have only a limited space. I don't want a fan there to take my space.	L8 starts gesturing with the fan prototype in her hand encompassing the work space and indicating its size
12:48		So, I want it to be hidden, maybe. Like in the car, you have a dashboard, and the aircon is actually hidden there. There's only a small window to let the air out, and I wish it could be the same.	L8 puts down the fan on the table and starts gesturing with both hands in mid-air to underline her words. In the end she picks up the fan prototype again.
13:06		So, maybe on the desk, there are holes to blow winds to you, directly to you, and the temperature can be controlled easily from a few buttons on the desk.	L8 hovers the fan prototype at arm's length above the desk with the left hand and then indicates air blowing towards her with both hands. She imitates pressing buttons on the desk with her right hand.
13:20		I would've preferred the device looked like this, and, yeah, hidden from me and easily accessible. Yeah, I think it will be a cool thing. Apart from that, I don't have any other comments. I think it	L8 keeps holding the fan prototype in her left hand and then puts it down. L8 slightly moves the fan on the desk.

TC	ID	Conversation	Gestures
		will be a nice thing, and if I get used to it, it will be an essential thing in my daily life, yeah.	
13:48	I	Okay, thank you. That's it.	

Participant L9

TC	ID	Conversation	Gestures
00:01	I	So, the scenario we're going to do is this one. So, it's a warm day outside, and the sun is heating up your office. Opening the window doesn't provide relief, and you have been given this personal cooling device to use. Please talk us through how you would use it.	
00:25	L9	First, I shall turn on this device, and then change it to the cooling, and maybe I will switch it to the middle, because I'm not sure the highest and the lowest, the feelings, and then I attach it to the fabric.	L9 first reaches then picks up the control unit. She adds the cooling layer to it. She sets the dial to 6 o'clock and puts the control unit onto the cloth on the table.
00:56		Then I wear the fabric, maybe as the coat, and putting it on my shoulder, and wearing it for some time. Then, if that's comfortable, it will remain on my shoulder.	L9 imitates putting the cloth around her shoulders.
01:12		If it's not, maybe I will put this device maybe on some other devices, and then trying to figure out which one would be the most comfortable. But personally, I prefer using the fabrics, because I like the distribution of the whole temperature.	L9 removes the control unit from the cloth and sticks it onto the fan. She keeps holding the fan in her left hand. She briefly touches the cloth on the table and gestures with her hands indicating a larger area.
01:42	I	Okay. So, would you mind putting this on, like, how you would put it on?	L9 places the fan on the table. She picks up the fabric and opens it up.
01:50	L9	Yeah. Oh, it is a scarf.	L9 places it on the table.
01:53	I	Yeah, but you can imagine it could be something else as well. So, it's just a cloth.	L9 removes the control unit from the fan.
02:03	L9	Yeah. So, the real device, it looks like this?	L9 holds the control unit up in front of her.
02:10	I	Yeah. I mean, that's the proposition. So, that's the prototype right now. Obviously, this is flat, so it would have a bit more.	
02:24	L9	Maybe like this.	L9 first wraps the control unit in the cloth. She then unwraps the control unit again, places it on the side and rearranges the cloth.
02:49		I'll wear it like this and put it here, because I don't like the cooling device is on my back.	L9 wraps the cloth around her shoulders, rearranges it slightly and then places the control unit where the two ends meet in the front of her upper body, like a

TC	ID	Conversation	Gestures
			brooch. She keeps holding it there and briefly points towards her back.
03:01	I	Okay, yeah. So, can you leave it on for a second, because we're going to continue the scenario. So, after a while, it's feeling a bit too cold. It's starting to feel a bit too cold. Please adjust the temperature accordingly.	L9 removes the control unit and looks at the dial.
03:22	L9	I switch to make it a little lower, but not to the limit.	L9 starts adjusting the temperature of the dial setting it to 3 o'clock. She then places the control unit close to her left shoulder.
03:35	I	Now, it's time for your lunchbreak. You're planning to leave the office for lunch. What would you do with the device?	
03:46	L9	I will take off the scarf and, together with this device, put it on my table, and switch it off, to save the energy. Then I'd go out for my lunch.	L9 removes the cloth together with the control unit from around her shoulders and puts it on the table. She then switches off the control unit by turning the dial to zero.
04:05	I	Okay, that's perfect. Okay, thank you. So, if you like, we can do one more scenario, and it's going to be this one. So, it's a cold September day. You are working in your office, but the space heating has not been switched on yet. You have been sitting at your desk for a while already, and are now starting to feel chilly. You have been given this personal heating device to use. Please talk us through how you would use it.	
04:40	L9	First, of course, I need to turn on the device. Sorry. And switch to the heating mode.	L9 removes the control unit from the cloth and exchanges the cooling for the heating layer.
04:54		I don't like the feeling of cold. So, I will switch to the highest heating.	L9 sets the dial on the control unit to the highest setting, to 12 o'clock.
05:08		Also, I will put it on this scarf, but now it's not a scarf. Maybe it's something will cover my leg, because when both my legs and feet feel warm, my whole body will feel warm. So, I place it on my leg, then I place the device...	L9 reaches for the cloth and starts arranging it. She opens it up and folds it in half, then places it across her legs. She places the control unit on her upper legs.
05:33		Or maybe I should also try using the device, put it on this device and use this device. Maybe place it on the floor and heating my feet.	L9 removes the control unit from the cloth and puts it on the fan. She keeps holding the fan up while talking and then places it on the table.
05:48	I	Okay, cool. Thank you. So, after a while, you notice that the device is providing too much heat, and you start to feel a little bit hot. Please adjust the temperature.	

TC	ID	Conversation	Gestures
06:23	L9	Lower it a bit, because the warm is better than the cold, yeah, and I then put it on my leg.	L9 removes the control unit from the fan and adjusts the setting to about 10 o'clock and then puts it on the cloth covering her legs.
06:37	I	Okay, thank you, and so now it's the end of the day, and you're ready to go home. What would you do with the device?	
06:49	L9	Turn off the device, but keep this measure, keep it remaining in this temperature, so the next day when I come here, I needn't to readjust it.	L9 removes the control unit and points towards the dial setting. She puts the control unit on the table.
07:05	I	Okay, yes.	
07:08	L9	Now, I already turned it off.	L9 removes the heating layer from the control unit.
07:13	I	Okay, thank you so much. So, this was the scenario part, and now I would like to know how useable and how useful that you find the device, and do you have any suggestions for alterations, changes?	L9 removes the cloth from her legs and places it on the table.
07:33	L9	Let me see. Personally, I think, I'd like to know the exact temperature of this device and the temperature of the environment. So, I'd like to make a comparator.	L9 picks up the control unit and looks at it.
08:02	I	Yeah, okay. So, does it mean you would want to read this information from the interface of the device?	
08:14	L9	Any interface. From a device or from the application also would be fine. Somewhere for me to know what is happening.	L9 keeps holding the control unit and briefly points towards the smartphone app.
08:25	I	Okay. Would you mind just... I mean... So, if you have a look at the app interface, it does provide some information. But...	
08:47	L9	Oh, I forgot the interface.	L9 puts away the control unit and looks at the app.
08:49	I	No, that's fine, but I mean would you mind just drawing what you would like to see, either on the app or on that? So, I have spare interfaces for you to draw on, and you can use these. I mean, you can also alter the interface itself.	The interviewer puts blank interfaces, one each for the app and the control unit, on the table in front of L9. L9 reaches for a pen.
09:26	L9	So, put this interface over this device. In the middle, there's some lights showing here. Six, seven. So, maybe all the light is turned on and it represents the highest heating or cooling. When only one light is turned on, it represented the lowest heating and cooling. When it's on the heating mode, the light colour is white, and on the cooling mode, the colour is the blue, this thing with the button.	L9 puts the blank interface on top of the control unit prototype. She draws some points on. She briefly reaches for the cooling layer.
10:18		But for the temperature, I prefer to read on some screen application. So, I saw there is the adjusting button on the interface, but I prefer to change the temperature through something that I can grasp.	L9 points towards the app prototype. She circles her left index finger over the slider on the app.

TC	ID	Conversation	Gestures
10:48		The interface... Oh no, here is the reading. So, all the temperature, humidity, the technical readings are listed here, but here, maybe there is only a button to show the running of this device. And one more thing is, maybe it's the ambient temperature shown here.	L9 looks at the app prototype and pulls the blank app screen towards her. She starts drawing on it. She stops and points at the lower part of the app prototype. She continues drawing.
11:50		So, yeah, I think this would be better because I like using the physical buttons or the knobs to adjust the temperature, not on this interface.	L9 finishes the drawing. She points towards the control unit and imitates turning a knob. Then she points towards the app interface she designed and then gestures over the old one.
12:06	I	Okay. Could you just provide the ambient... what you just said on there as well?	The interviewer points towards the proposed screen. L9 picks up the pen again.
12:14	L9	You mean I write the ambient temperature?	
12:17	I	Yeah, just for me to know afterwards.	
12:24	L9	Maybe the wrong spelling. This is the lights. Do I need to do that here?	L9 writes on the app screen. After she finishes, she points towards the control unit drawing.
12:46	I	Yes, please.	L9 picks up her drawing.
12:48	L9	I think I draw pretty good.	L9 holds up her drawing.
12:51	I	Yeah, thank you. Very readable. Okay. So, thank you very much.	L9 places the drawing on top of the control unit prototype and puts away the pen.
12:59	L9	You're welcome.	

Participant L10

TC	ID	Conversation	Gestures
00:01	I	Okay so we're going to have the following scenario. It's a regular office day and you've just come into the office from outside and you feel slightly hot from walking in the cold and coming into the warm office. You've been given this personal heat and cooling device to use and please talk us through how you would use it -	
00:22	L10	Okay.	
00:22	I	- in that situation.	
00:31	L10	I think I'm going to put this thing on this and then put it like in front of me, and just turn on. Do I need to put that...?	L10 picks up the control unit and puts it on the fan. She places the fan at about an angle of 45 degrees on her left. She reaches again for the control unit and removes it.
00:48		I think I'm going to first turn it on, no I'm going to use my phone. So, I put it on and I'm going to use my phone to switch it on to the cooling part,	L10 starts adding the cooling layer to the control unit then removes it and places the control

TC	ID	Conversation	Gestures
			unit back on the fan. She picks up the app prototype.
01:01		and I think it's just working, I mean in the first process I'm going to make it very cool, like in the lowest temperature, so that I can get a..., so I can feel cooled down. Then like after I feel better, I will just turn it off from the phone, I think.	L10 points towards the fan and rotates her left index finger. Then she moves her finger along the slider on the app to the lower part of the scale. The interviewer adds the cooling layer to the control unit. L10 presses the on/off button on the app.
01:36	I	Okay, then after a while, so you've been sitting in your office for a while, and you said you've already switched off the fan, now you're feeling a bit chilly, you're starting to feel chilly, so what would you do?	
01:53	L10	If I feel a little bit chilly I will, like, I will let it be but if it's still like for a long time or, like, it's get more chilly I will try to make it like make it heat into the heat set up, so I'd try to use the... this one, right? Turn it on.	L10 indicates towards the upper part of the scale on the app. She puts the app down and removes the cooling layer from the control unit on the fan. She picks up the heating layer and places it in the control unit.
02:31		I, like, for this I would probably try to use the phone as well because I can get the direct information, like what the temperature is and now, so I might want to control it like very precise. So, I would say okay, my body... oh, it doesn't give me body temperature.	L10 picks up the app prototype and changes the screen to heating. She points on the app screen.
03:00		So, I would see what's the current temperature of the surrounding is and then I'd put it like two centimetres higher, like make it higher according to the number here, yeah. So, I think I would mostly use the phone I guess. So, will it directly go to like the right place if I change it here.	L10 makes a gesture towards her surrounding environment. She moves her finger up on the slider on the app. She then points towards the temperature indicator showing it to the interviewer. She points towards the control unit on the fan.
03:37	I	It's a good, good question. Yes, it should.	
03:40	L10	Okay.	
03:41	I	I don't know if that's feasible.	
03:43	L10	Okay, so if I change it here so it goes like, working that's why, there, yes, I think it's what I'm going to do.	L10 adjusts the dial on the control unit.
03:55	I	Okay, and then it's time - yeah, it's not on there. So we're still in this scenario but now it's time for your lunch break and you're planning to leave the office for lunch, so what would you do with the device?	
04:12	L10	If I still I feel cold or warm, if I'm going to the lunch I definitely will make it like with something like this. So, if I feel cold, if it's in the heating part, I would try to do it like in this part, I will put it on here, be in the back. So, I already feel cold at this part, so I will do it like this.	L10 removes the control unit from the fan. She picks up the cloth and wraps it around her lower back and fastens it at her belly. She first places the control unit in front then on the lower

TC	ID	Conversation	Gestures
			back. L10 indicates towards her belly.
04:52		If it's you know, I feel warm, but I want... If it's in the cooling setting, I think I'm going to wear it... I don't know. If it's in the cooling setting.	L10 removes the control unit from the back. She removes the cloth from around her lower back and belly.
05:10		I think I'm going to wear it like on my shoulder I guess, just like this so that it's going to evenly cool me, cool me down - is that right? Okay. Like here or maybe just my shoulder, I guess.	L10 puts the cloth around her shoulders. She puts the control unit on her right shoulder. She briefly tries to put it on her back before placing it on her shoulder again.
05:29	I	Okay.	
05:30	L10	Yeah, and if I come back I will put it on here again.	L10 removes the control unit from the cloth and puts it back on the fan.
05:36	I	Okay.	L10 removes the cloth.
05:38	L10	Yeah.	
05:41	I	Okay, so you've been working in your office again and now it's the end of the working day, and you're getting ready to go home. So, what would you do with the device?	
05:54	L10	I think I'd turn it off first, and I think I will leave it at my office, and yeah, I definitely leave this thing to my office, because usually I don't want to bring that much things at my back, it's a bit heavy. So yeah, I will, I might just leave it like this, yeah, and turn it off of course, yeah, like take my phone.	L10 touches the control unit on the fan. She touches the control unit repeatedly and in the end picks up the app.
06:33	I	Okay, great, thank you very much. So that was the scenario, and now I wanted to ask how usable did you find the device and how useful? Do you have any suggestions for changes or alterations, like, something that didn't work for you?	
06:57	L10	The only thing I feel like I have doubt about this thing, like I mean how is it wear, how what it looks like. I mean if I'm in the office, like, like I mean, how would it look like compared to my clothes every day.	L10 grabs the cloth briefly than gestures around her mid-body area. She points towards her top.
07:22		So, I don't want to look, it looks like something like medical thing or want it looks cool. So, because like I mean if you're, I'm going to the lunch to eat with the colleagues, it's going to be a little bit weird if I wear something really weird, so I'm...	L10 briefly touches the cloth.
07:54		This, how this thing looks like definitely going to affect my decision if I'm going to buy it or use it.	L10 touches the cloth.
08:05		But this part, I mean it's quite useful because I was in office like in engineering building, it's very hot in the summer, so it's definitely useful to get one at the office.	L10 touches the fan.

TC	ID	Conversation	Gestures
08:22		Because like I see like the other lecturers, they've got their own fan, like in front of them, because even though we've got the cooler, like the conditioner, is that conditioner? Anyway, but it's like the noise is very big, so they have their own fan but it's still very hot, so they open the door.	L10 outlines a large fan in mid-air.
08:47		Like if the thing is quiet enough and it's just like this size it will be really great, yeah. Like, I mean, for me the use would be more, the thing would be more useful in summer I guess, like in the winter, we've got the heater in office, so it's warm enough. Yes, so yeah.	L10 points towards the fan.
09:25	I	Can I ask you one more thing because you mentioned, would like the wearability or the usability would also depend on the look of the wearable part, so do you have any idea what you would like it to look like or is there...?	
09:46	L10	Yeah, I mean if it just looks like in this way, I feel it's good, I mean for example, you've got like different textures, like different pattern of this scarf and like for example, like usually in the office if you feel cold, you have like a scarf over here, or a coat.	L10 points towards the cloth. She picks up one and unfolds it. She wraps it around her shoulders.
10:10		So, it would be great if you just attached to this part, and if it can really evenly distribute the temperature, it would be really nice.	L10 removes the control unit from the fan and places it on her right shoulder.
10:26		So, because the thing I mentioned before is usually I saw this wearable thing, they've got a black band, like you just wear it like you got like, it's very ugly.	L10 gesticulates around her mid-body area.
10:41		So, because I think it's, like for me like, if you want to be cool or be warm enough, you really by doing it with your clothes, you wear more clothes or less clothes.	L10 removes the control unit from her shoulder and puts it on her upper arm.
10:59		So, this thing is the most common way for me to get my own temperature and comfortable. So, I think this thing looks like a scarf, a scarf already, so this would be good for me, yeah.	L10 removes the cloth from around her shoulders. She puts it back on the table and removes the control unit.
11:23		Okay, thank you so much. That's all ready it.	
11:27		Oh cool.	

Participant L11

TC	ID	Conversation	Gestures
00:01	I	The scenario. So, it's a warm day outside and the sun is heating up your office, opening the window doesn't provide relief, and you've been given this personal cooling device to use. Please talk us through how you would use it.	

00:23	L11	If it's a wearable, it will be the wearable that would be given to me? Presumably.	
00:29	I	Well, you basically have this kit, so it's up to you.	
00:33	L11	So, I either have that or I have this, yeah.	
00:35	I	So, you can use either the fan or the wearable or a combination.	
00:40	L11	Well the fan probably wouldn't make any difference because if the windows open, it will probably already generate some breeze and if that's not helping. I personally think that the fans are not particularly effective in general. I mean, I guess it can generate, that it will be noisy, and it will have to be very close to me and probably others would complain as they often do, if I use the fan. I think our office is a pretty good example upstairs.	L11 picks up the fan and moves it close to her face and back. She places it back on the table.
01:12		So, I'll probably not use the fan for that reason and in fact those kinds of fans without cooling and stuff they do exist, like you can have a little thingy and they're not, I just find them silly.	L11 moves the blades of the fan.
01:27		However, putting them in a scarf would be amazing. So, if you had a, and not just because it's a cloth, just because I love wearing scarfs. But having a scarf, I like to wrap it around myself because a lot of the heating cooling happens around the neck as well, right? So even if there is a distribution, even if like here it gets cooler that's probably okay.	L11 picks up the cloth and wraps it around her neck. She indicates around her neck and then down the front along the scarf.
01:54		Well the other way around sorry. Even if they heat up that means the normal temperature that will be okay. But if this would get cooler that would be amazing.	
02:05		So, if this assuming this could be maybe flexible of some sort. So, I would, I can almost use it as a broche. Or if it's completely hidden that would probably be the best. Hidden somewhere at the back but that may have to be a little bit smaller probably for that.	L11 picks up the control unit and puts it on the scarf close to her throat. She moves it then towards the back of her neck.
02:25		But I guess if the distribution can arise in the size of that. Probably just, it's probably a battery and a micro-controller so it could probably be smaller I think.	L11 moves the control unit back to the front and looks at it. She indicates towards the cloth.
02:41		Yeah. I would just, and that would actually be awesome because of the scenario happened to change then I'd get really cold sudden, all of a sudden or whatever. Like in the States they switch on air conditioning and it's actually awful because I freeze all summers. It's ridiculous whenever you're inside.	L11 tries to fasten the control unit at the back of her neck but then brings it back to the front.
02:59		So, but they're amazing if you don't have to change your scarf. I love scarfs right. So, it would be cool if we can, actually be cool if I could have many scarves with these things and I	L11 points towards the scarf. She imitates switching between different scarfs. She points towards the app and then fastens

		can just... That's probably how I would do that, but I would control it through this rather, because I think I would rather have to be this. I'm going to leave it there for now.	the control unit at the back of her neck.
03:25		Incorporate it, maybe on/off of some sort could be here. But, it would be amazing if I had, if I could pre-set the temperature on this and because say I know that I am roughly comfortable where they're 24, 25 degrees outside, right.	L11 points towards the control unit at her back. She then moves her finger along the slider on the app.
03:51		So, if it can detect the ambient temperature and not cool too much, could not cool down but just have that, yeah. So, if it's 40 degrees outside then it can, it knows.	L11 gestures with both hands, indicating an equilibrium or balance.
04:05		So, it probably pre-set this, but I would probably like to switch it on and off here somewhere. Wherever it is, dangly things. So, yeah.	L11 moves her left index finger across the app screen and indicates with her right hand along the scarf.
04:20	I	So, could you please switch it on for now using what is available.	
04:25	L11	Alright, well I'm going to switch it on with this, this button. On no, because I'm doing it first time, right? Alright so put that on, I go. Quick this is on, right?	L11 presses the button on the control unit at the back of her neck. She indicates wrapping the scarf around her neck. She presses the button on the app.
04:44		Then I would go, cooling is... to the, somewhere here.	L11 looks at the app screen. She puts the cooling screen on. She indicates a point slightly below the centre.
05:00		It would be nice if it was like, so there, it's funny because my hands would be used to either switching and confirming that I've switched or if I knew in advance that that will just have a pre-set temperature. If that's all, I think in a simplest way I would get, you turn on the App, you get here, you just pre-set the temperature and I would just close the app, I would not be using that, right?	L11 enacts selecting a point on the scale and pressing to confirm. She points towards the on/off button on the app screen.
05:32		Because I just would want to make sure that I have it all set up first and then if I'm in an environment when it's too hot and the window is not providing any relief, I'll be like 'hey, I'm already wearing this pretty scarf', so I am just going to go ka-ching! and it knows what temperature I like then it goes down and if I think the, yeah, and presumably adjust itself to either cooling and heating.	L11 points towards the scarf and switches on the control unit at the back.
06:01		I mean just based on the ambient temperature. Actually, what would be cool, this is the only interface that's available right?	L11 points towards the app.
06:13	I	Right now, yeah.	
06:16	L11	Yeah, okay. Because it would be nice to, I don't know if I would say if I were not controlling it on here directly at all times, I would probably just enter my preferred temperature and that's it.	L11 is hovering her fingers over the app. She indicates typing in on the app.

06:38		Then I would be just. Maybe I'd have another screen actually where you can just have a pre-set and then in case if you ever need to control something say you have a code and then you're too hot and too cold.	L11 points towards the app.
06:52		So that's a different scenario. Say if I didn't have access to control the temperature in that, I would control it here.	L11 picks up the app prototype. She briefly hovers her hand over the control unit at the back of her neck, then shifts the focus back on the app.
07:09		But is, yeah. I would kind of want to have a pre, ideally, I'd like to have pre-sets for either or and then maybe like the arrow for that and the arrow for heating. Going both ways, or yeah.	L11 puts the app prototype back down on the table and indicates at the opposite points on the scale.
07:32		But if it had, say, 31 degrees is my pre-set or if I, you know, dropped it to whatever and that's where it sets then, just click...	L11 hovers with her right index finger over the screen.
07:45		There is all kind of stuff here. That tells me what the ambient stuff is right? Body temperature, power level, humidity. Power level, that's the battery from...	L11 points to the information section on the lower part of the screen. She points towards the control unit.
08:04	I	Yeah.	
08:06	L11	Cool. Yeah, I don't think I'd want to see any of the stuff on the scarf. I think if I needed to check, I don't think I would always want to know what my body temperature is already. What the humidity is, once I know gosh it's humid. Is it really that humid, oh yes, it is? That would be good. Yeah. Does that make sense, or do you want to have more details on anything?	L11 briefly puts her hand on the scarf.
08:41	I	No, that's fine for now. We're going to continue the scenario. So now it's time for your lunch break and you're planning to go out for lunch. So, what would you do with the device?	
08:54	L11	I'd keep it on because it would know outside is hotter. So, it is a hot day, right? So, I would just keep it on and I would assume that to the pre-set temperature, it will adjust and if I just feel like it's actually very different because there's a lot of wind blowing, and I do not feel so hot, I will just turn it off.	L11 checks the scenario text. She gestures wind blowing and then reaches for the control unit at the back.
09:17	I	Okay. Yeah that's fine.	
09:19	L11	Or turn it off, or whatever the off button is.	L11 indicates towards different positions.
09:25	I	Well thank you. If it's okay, we would switch to another scenario. So, it's this one. It is a cold September day, you're working in your office, but the space heating has not been switched on yet. You've been sitting at your desk for a while already and are now starting to feel chilly. You have been given this personal heating device to use. Please talk us through how you would use it.	L11 removes the control unit from the scarf and the scarf from around her neck.

09:56	L11	I think it would probably be quite similar, right. So, say if I had a scarf, although from personal experience, I used to wear these open finger gloves in these kind of situations. That would probably quite nice as well. Although I think scarf probably does that, cause you can always...	L11 picks up the scarf again and again wraps it around her neck. She points towards her hands and fingers and imitates a typing movement. She wraps the ends of the scarf around her hands.
10:17		No, I think scarf is good. So that will be the device inside the scarf somewhere. Nice, cosy, warm thing or just cosy. So, I would turn on the phone, pick the app, come here and similarly I would either have a separate screen where you can, or where it already has a pre-set or I would go into the heating bit to whatever my preferred heating temperature is and leave it there, set it as a default, click here and then and press there and hope that it will start heating up without [inaudible 11:17]. I mean, I may also ask for a delivery of tea but there would be no [inaudible 11:18] option like that. Forget it.	L11 puts the control unit at the back of her neck. She removes the cooling screen, presses the on button on the app. She puts the heating screen on and indicates setting a temperature and confirming. She then presses the on button on the control unit.
11:25	I	So, you've been working with the scarf on for a while and you notice that the temperature, actually, you need a little bit more heat. So, you still feel a little bit cold. So, what would you do?	
11:41	L11	I'd pull out the phone and press the button and open it up and adjust the temperature setting. Close it and assume that will affect that.	L11 enacts opening the app, adjusting the temperature on the slider, confirming it and pressing the home button to close the app. She points briefly towards the scarf.
11:55	I	Then it's the end of your working day. You're getting ready to go home. So, what would you do with the device?	
12:06	L11	Am I given it for forever? Or am I given it just for the office hours?	
12:11	I	It would be yours.	
12:13	L11	Then I'll take it home and if it's, I assume that the temperature sensing would carry on and it's pretty cold outside still or already and yeah.	
12:33		I would wonder though if I keep it at home how would I wash it at some point. But I guess that's part of the system that's part of the unknown, unvented bit. I assume that they were, that's going to be resolved because that's a lot of problems with the wearables, clothing.	
12:58		Yeah, I'd come home and take my coat, take my... like, turn off, take my scarf. Maybe I could assume that if it has some sort of a built-in thing that if it's, the ambient temperature between outside and inside is not.	L11 imitates taking off her coat. She switches off the control unit at the back of her neck.
13:28		Yeah, I may forget to turn it off. But if it, maybe it has some sort of thing where if it hasn't been, if there is no movement detected on it and if the ambient temperature is roughly the same, so after about 15 minutes or something it will just switch	L11 leans back. L11 is moving slightly with her upper body. She gesticulates.

		itself off. Or I don't know how it may detect that I'm still wearing or not.	
13:53		But I think, if you're wearing even if you're just typing you still do micro moves of some sort and I think if it's a, say if it's a scarf you'd notice that. If it was anything else, you'd probably notice that after a while. Although it could be as bad as the light switches sometimes when you sit too still. It doesn't detect your fingers and turns the lights off. I don't know if you've ever been in that situation. So, I, so it would be nice yeah. Because then in case if I forgot to. So, if I hung it on the things, it's not eating up the battery, yeah. In which case I probably would never switch it off.	L11 imitates typing and is moving slightly doing so. She briefly touches the scarf.
14:35	I	Okay, yeah. Thank you very much. So, we are through with the scenarios. You've already mentioned you're in a scenario, some changes that you would suggest. So, the question is how useable and useful was the device?	L11 removes the scarf and the control unit.
15:02	L11	I think it would be very useful. I've been in both of the situations many times and you only always wish you had some sort of, how do you get relief, and in fact they're slightly different situations that carry on, like given now. So, I wear a scarf almost all the time. In different weathers, different type of scarfs clearly but they are one into the tube. I have to take it all off but if I could. In fact, if it automatically could detect that it's too hot relatively to my preferred temperature it can maybe automatically goes between the two, cold and hot. So, it's, so I don't have to go and turn it down. If it's smart. [laughter]	
15:49		So, I think I would probably, yeah, I can see the value of adjusting this on occasion, but I think it's more like I would probably just go with a pre-set rather than taking it all out. In and out all the time.	L11 moves with her index finger along the slider on the app screen.
16:06		I mean can possibly incorporate if there are some very, very simple tactile buttons within the artefact. Where you can go... it's almost like that neutral space doesn't really exist, right?	L11 takes one of the ends of the scarf between her fingers. She indicates to the neutral point on the app slider.
16:26		It's in fact you always just have either hot, it's like with sound right, so you have no sound completely, and terrible super loud sound and that in-between thing on some devices you see there is a medium optimum or whatever.	
16:46		But in fact, all you really want is like this: 'I want it a bit hotter', 'I want it a bit cooler' and so maybe that like smaller adjustments can happen in the, at the real time on the article but I think the pre-set can just happen here or on the computer for that matter. No, probably here.	L11 presses imaginary buttons on the end of the scarf. She then points towards the app.
17:08	I	Could you draw this interface or also build some or make these? Yeah could be just post-its.	L11 takes an empty screen and post-it.

17:26	L11	So, I would just at the, again if it's a scarf in this case, at the bottom of the scarf. I would just have, what is it. Just a discreet tactile button maybe, and an off just in case. So, I think that will be, I would make this much, much smaller. Like I think a small. Do you need me to write anything in that? Just so it's much smaller. Or are you good?	L11 draws on the post-it. She then briefly touches the control unit.
18:39	I	I think that's fine.	
18:41	L11	Yeah, actually in fact. Yeah so if this is, if I could have the buttons here, and if the battery's hidden somewhere around the, like the middle of the thing because that's probably where the most balance will happen.	L11 points towards the end of the scarf. She points towards her neck afterwards.
18:53		Because you can run that wire... But yes, anyway.	L11 indicates a wire running along the inside of the scarf.
19:03		But for this, I would probably... There is that thing. I'd probably have like a preferred temperature that you can click on and, oh sorry, and then I would have ambient temperature, body temperature, and humidity and then battery.	L11 puts the empty screen on the app prototype and starts drawing and writing.
20:22		I'm so sorry, you know like the real time, and that's probably it. I don't know if I would have a set button or not. Because in some ways, like, if you just adjust this then you could and maybe there is an option like cooler, hotter and you kind of just go like this, one way or the other. Just in case if I needed to. Or you know you're going to go plus, plus, plus. I think sliding is a bit fiddly. Yeah. I don't know, yeah that's probably.	
21:26	I	Thank you.	
21:28	L11	I'm excited.	
21:30	I	So, this was that part, or just maybe one more question regarding this. Would you change the interface as well or just make it smaller?	The interviewer points towards the control unit.
21:40	L11	I would, because I think if it's in, if it's on the fan, it makes sense to have the, like it's nice although if it was on, say hypothetically if it was on the fan, I'll probably rather than having it on cooling versus heating I would probably just have something similar to that where it's... How would you do that? Because it increases both ways, right? So, like to use your thing, it probably has something that has that. So, it's like hot and then cold. So that you can slide it around and I mean it would be, yeah. So maybe instead of seeing the change here if it's cooling or heating maybe you can just see it on that and based on the pre-sets maybe you could just see this is where the bar is happening, this is my preferred level and then you can see automatically if it's, if the ambient temperature is below or above. Maybe you can just slide this preferred level back and forth a little bit. If you	L11 picks up an empty control unit screen and starts drawing.

	say today I'm too, I don't know. I just had a nice big hot cup of tea and I do not feel so cold so let me adjust it for a little bit.	
23:27	But I think that would be only on the object. If it was here, I probably would not want to have anything other than, like ability to plus, plus, plus, plus, plus, or plus, plus, minus, minus whatever. Just like a volume control and maybe an ability to turn it off completely. But I would just not have any of the stuff. If that makes sense.	L11 puts the control unit on the fan. She then points towards the cloth.
23:57	Because I think if they're completely different scenarios here it, by the nature of wearables, even if you put it, I think unless you put it in some rigid belt or something even, so you'd probably need it flexible or small. Like they have these flexible batteries somewhere now. But I would probably concentrate most of the things, most of the packet like, most of the heavy stuff in the centre behind the back. So, the rest can be just scarf. Unless things I've seen actually for volume. I think it's one of the earlier wearables that they've ever made that's integrated in clothes and they actually just embroidered fabric buttons. So not embroidered they are like the, you just see the circles or squares I forgot what they were. Just stitched, other than that it's just. So, this can be very discrete, and they totally not heavy because they're just fabric. So, I would do that.	
25:06	Okay, well thank you so much.	

Participant L12

TC	ID	Conversation	Gestures
00:06	I	Okay. So, we have the following scenario. It's a regular office day. You've just come into the office from outside, and you feel slightly hot from walking in the cold and coming into the warm office. You've been given this personal heating/cooling device to use. Can you please talk us through how you would use it?	
00:33	L12	So, I need some cooling. I mean, I first imagine where it will be the warmest on my body. I think it would be somewhere... to be honest, certainly on the legs, and I want to start working. So, I don't really want to put on anything.	L12 touches first his upper body and arms, then his upper legs.
01:00		So, maybe I'll just put on some heating first, and then, yeah, maybe I'll set the strength, but only some. I mean, the feeling of warmth will subside in a few moments, I guess, because my body has to cool down after walking. So, this will only take a few minutes. So, nothing really	L12 picks up the heating layer and puts it in the control unit. He sets the heating to 30% and tries to stick the control unit onto the fan, at first, the wrong way around.

TC	ID	Conversation	Gestures
		to worry about there much. So, I'd put it in here. How can I tighten this?	
01:46	I	Adjust it the other way around.	Interviewer points to the Velcro strap at the back of the control unit.
01:50	L12	Ah, okay. I'll put it there, like this. Maybe if I could lean it towards something else, I would put it like this, so it faces my chest, and then I continue working, or I start working, rather.	L12 turns the control unit around. He places the fan at the table edge close to his upper body but slightly to the left. He tilts the fan backwards slightly.
02:19	I	Okay. Yeah, so you've been working for a while, and you notice that the temperature doesn't suit you, because your body has cooled down. So, please adjust the temperature, if you would adjust it, I mean.	
02:36	L12	Yeah. I don't know how easy it is to adjust the temperature here. So, unless I've set it up right here, but I could imagine myself now going into the app just to quickly, like, turn it off again. Just press a button, and then it would automatically turn off, and that's it basically, yeah.	L12 reaches for the fan again and points along its upper edge. He lets go of the fan and reaches for the app prototype moving his fingers over the screen. He then presses the on/off button.
02:59	I	Okay. So, now after a while, you're feeling a bit cold.	
03:07	L12	So, next scenario?	
03:10	I	Oh, I have some additional stuff always for the one scenario. So, where on your body would you feel cold in that case, if you've cooled down?	
03:26	L12	My legs, my feet and maybe my hands too, yeah. They're the kind of areas that tend to become cold first, yeah.	
03:40	I	Okay. So, in that case, would you use the device if you feel cold on any of these parts?	
03:52	L12	Yeah, maybe it should be better to start, well, to start walking again. So, I'm then happy to sit around in the office all day, or maybe getting cold is a sign that you have to move your feet to get the blood circulation going again.	
04:13		But presumably, I have to continue working now, and I can't just take a break. If it's only my legs and feet, then I would try this one, the set-up right here, and put it under the table facing my feet, and then my feet would get warmer, and then my legs would get reasonably warm as well. So, that would be my solution.	L12 places the fan prototype on the floor next to his feet.
04:43	I	Okay, cool. Okay, so now it's time for your lunchbreak, and you're planning to have lunch outside the office. So, what would you do with the device, now that it's set-up like this?	
05:01	L12	Yeah, I don't need it anymore at the moment. So, yeah, it's down there. So, I use the app to turn it off, and, yeah, that's it. I mean, I assume that there's some other heating devices to keep the	L12 presses the on/off button on the app.

TC	ID	Conversation	Gestures
		room itself warm, right? So, yeah, just turn it off with the app, because I'm lazy.	
05:28	I	Yeah, okay. Thank you very much. So, we do one more quick scenario. So, it's this one. It is a warm day outside, and the sun is heating up your office. Opening the window doesn't provide relief, and you have been given this personal cooling device to use. Please talk us through how you would use it.	
05:59	L12	Yeah, it'd come up here again at first, I don't need you down there. So, I would... no, I wouldn't use those settings here, I think.	L12 picks up the fan from the floor. He tilts it and touches the control unit at its back and then puts the fan at about arm's length to his left.
06:16		I would use this one right here. So, I would start up the app again. Oh, I can see my own body temperature there. Okay, that's interesting.	L12 puts the cooling app screen on the app and looks at it.
06:36	I	I mean, that's only if you're wearing the...	
06:42	L12	Some sensors.	L12 continues looking at the app screen.
06:42	I	Yeah.	
06:48	L12	Is it running on battery, because it's talking about power level?	L12 points towards the fan.
06:54	I	Yeah. So, the idea is that it has some sort of battery, but, obviously, you would have to charge it every now and then.	
07:01	L12	Okay, but if I'm sitting at my office, I can just plug it in anyway?	
07:05	I	Yeah.	
07:08	L12	Yeah, okay. Alright. I would think... Okay, let me think about this. I'm tempted to, like, face it straight away towards my own face, but I get the feeling that I shouldn't really do this for longer periods of time.	L12 picks up the fan and moves it towards his face. He puts it back on the table.
07:38		So, I'm going to face it towards my chest again, and then turn it on, as I said here. Turn it to cooling. Can I set the temperature to, like, a specific temperature that should come on or something? I would just use, yeah, 21 degrees sounds good.	L12 adjusts the position of the fan on the table. He presses the on/off button on the app.
08:06		And then yeah, set it on a low fan strength because cooling tends to be annoying if it's blowing too harshly into your face and stuff. So, yeah, just a slight volume of air coming in, that's slightly cooler than what's currently inside.	L12 reaches for the fan and slightly readjusts its position. He imitates air flow coming towards his upper body.
08:41		Although, I forget the clothes until now. So, maybe I could use them too. I mean, it would be really cool if I got a hat. That would be really cool, and then I can put it on, and then it would be like cooling my whole head. So, I can pretend it's a hat, right?	L12 briefly touches the cloth on the table. He outlines a hat on his head and imitates putting it on.
09:19	I	Yes.	

TC	ID	Conversation	Gestures
09:19	L12	Yeah. Okay, if I can pretend it's a hat, then I'd just, yeah, put it on like a hat, really. Like this, and then maybe a little bit into the neck, but I'm not so sure, and then put it in there, across, right? So, like this, and set it to cooling, but you get the idea, right?	L12 picks up the cloth and balls it up. He puts it on his head and arranges it so it falls into his neck. He removes the control unit from the fan and puts it on the cloth on his head.
09:55	I	Yes, okay.	
09:56	L12	Okay. So, this is what I would try out too, at least here.	L12 removes the cloth from his head.
10:01	I	Okay, thank you. So, now it's the end of your working day, and you're preparing to go home. So, what would you do with the device, in case you were still wearing it?	
0:17	L12	But it's my own, right, so I take it with me. It's still a hot day?	
10:38	I	Yes.	
10:38	L12	Okay, still that scenario, right. I think I'd just leave it on as it is, right? If I'm using the hat set-up, for example, I would still use it, and then maybe even turn it up a little bit, because, as soon as I move out and start walking again, it's getting even worse than just sitting around in the office.	L12 picks up the cloth and puts it on his head again.
11:07		So, yeah, I would use the same cooling hat set-up, but just with a little bit higher strength right here, and then I would leave, yeah, and take my smartphone with me, so I can adjust it on the go. So, I don't have to, like, fiddle around here, so yeah.	L12 puts the cloth back on the table, then changes the setting on the control unit to about 70%.
11:30	I	Okay. Thank you. So, yeah, those were the scenarios. Now, how useful and usable did you find the device, and do you have any suggestions for alterations?	
11:51	L12	Well, it's difficult to say, isn't it? I mean, I don't really know what to say because, basically, I can imagine myself, how it's really used in the end, right? I mean, in the sense that this can basically stand for every possible clothes I could imagine, I think it's very useable, right, because you could wear it as a hat, you could wear it as a pullover, shirt, whatever, gloves. So, in that sense, it would be very flexible because you can use it for many different purposes.	L12 picks up the cloth and moves it to his head, upper body, and hand.
12:40		And you could also use it as a normal, like, cooling or heating device for standing around. I guess if you take this, then it's a little bit annoying to adjust the angle right here, but, otherwise, I think it's very useable. I mean, it depends on how long the battery is going to last and stuff, you know, and how much cooling it can really do, and everything else. So, yeah, I don't really know what to say otherwise, you know.	L12 reaches for the fan and moves it around slightly. He lets go of the cloth and tilts the fan in different angles with both hands.

TC	ID	Conversation	Gestures
13:19	I	Okay. No, thank you. That was already very helpful. Do you have any suggestions how you could adjust the angle, for example?	
13:36	L12	Okay, suggestions I would like to implement in the end, yeah, I would set this up on a turnable device, so you can just turn it around in whichever direction you want, and also make this a degree of freedom, so it changes the angle, at least a little bit.	L12 picks up the fan and holds it in mid-air in front of him. He rotates it around its y-axis. He then rotates it around the x-axis.
14:01		I mean, it doesn't have to be this, but at least maybe this and this. So, are you just talking about the normal set-up or are you also talking about suggestions for clothes?	L12 tilts the fan. Then he rotates it again around the x- and y-axis. He briefly touches the cloth.
14:19	I	Yeah, both.	
14:20	L12	Both, okay. Yeah, for clothes, obviously, what I said before, the hat would be cool. The gloves would be very useful. I guess something along the arms, like an arm sleeve, just the arm sleeve, and shoes. I mean, that's obvious, right? Shoes should be very useful for heating up, and some kind of leggings maybe that you can put on. So, yeah, that would be my suggestions.	L12 puts the fan back on the table and picks up the cloth briefly.
15:07	I	Okay. Well, thank you very much. So, yeah, basically, those were the parts that I was going to record. So, I'll switch off the video camera.	

Participant L13

TC	ID	Conversation	Gestures
00:01	I	The scenario – it's a cold September day, you're working in your office, but the space heating has not been switched on yet. You've been sitting at your desk for a while already and are starting to feel to chilly. You've been given this personal heating to use and please talk us through how you would use it.	
00:20	L13	Okay, if I feel cold and it hasn't, the central heating inside my office hasn't been turned on, I would just try with this input interface. I will start from icicles at the beginning is the starting temperature would be the current temperature in the room. So, I would start turning it towards the increasing temperature just a little bit, because this is my first time. I'm not sure how strong the system is, I mean the heating and then I feel myself again, if it's better I mean if everything was slightly warmer and then if I feel like that I would stop there and if not, I would just turn it bit by bit, bit by bit.	L13 picks up the control unit. She sets it to about 2%.
01:24	I	Thank you. So, it's set to heating with a red light on. So, what would you use it with?	The interviewer adds the heating layer to the control unit.

TC	ID	Conversation	Gestures
01:37	L13	This one? Now the red light is on. So, I suppose now the temperature has been increased but I'm not sure how much I would use my body to feel if it warm enough. I would leave it like that, but as the time goes by I would feel my temp, my body again and if it's too warm I suppose that I could press that button to stop the heating.	L13 points towards the control unit. She gestures and presses the on/off button on the control unit.
02:14	I	Okay, yeah.	
02:16	L13	So, yes, or I might turn this just down a bit to decrease the temperature. Yes.	L13 lowers the temperature setting on the control unit.
02:32		I'm not sure actually if I should press that button or I should decrease a temperature down with this char.	L13 points towards the on/off button on the control unit first, then on the needle.
02:43	I	Okay, could you please show me how you would, where you would put this device then on your body if that's what?	
02:55	L13	This device? So, if it's on the scarf it might, it should locate somewhere around here or at the end of the scarf or somewhere I can reach easily.	L13 holds up the control unit. She briefly touches the scarf and then places the control unit at her left shoulder.
03:10	I	Can you please show me?	
03:13	L13	Yeah, for example I'm wearing this one. Oh, so you mean that this badge is also the heating element itself? Okay. I assume this scarf is a conductive scarf. I suppose that if I stick it there the heat would run through the scarf.	L13 picks up the cloth. She briefly holds up the control unit. She puts the cloth around her neck and places the control unit at its end. She gestures along the scarf.
03:47		If it's nice I would just show it off like this, and yeah leave it there. So, I think here is quite practical for me, so I can adjust it without seeing it once I have used it for a while. Yeah. So, I don't have to look at it.	L13 puts the end of the scarf with the control unit over her shoulder. The control unit rests at her collar bone. She imitates adjusting the temperature.
04:09	I	Could you just do it like, so after a while the temperature doesn't feel.	L13 is starting to remove the cloth.
04:20	L13	Now I feel the needs the temperature increase, so I would go a bit slightly, I would think that that is one degree up. Wait a bit, maybe it's still cold in place a bit. Maybe leave it there, maybe for a while and then I'm happy.	L13 readjusts the cloth around her neck. She turns the indicator on the control unit to increase the temperature.
04:49		And maybe now the central heating has been turned on and I feel a bit too warm. I would adjust it, decrease the temperature. Yeah, and maybe I think I can, the outer part of my body still needs some warm and I would just use this scarf. An outer part of my body is... I would just put it there, yeah, I think so. I would put it there, yes. I don't want to damage your beautiful scarf.	L13 turns the indicator on the control unit to decrease the temperature. She removes the control unit. She places the scarf over her upper legs.
05:35	I	Continuing the scenario, now it's time for your lunch break and you're planning to leave the office for lunch, so what would you do with the device if you were still wearing it?	

TC	ID	Conversation	Gestures
05:48	L13	Well if it's wearable, I would just wear it, all the day, if I can have hold of it all day or any time actually, yes. But if it's a fan, it's not practical to use it, you know, when I travel. I would just, I think I would leave it on my desk for example.	L13 puts the scarf together. She briefly points towards the fan.
06:19		And now it's still cold. I would increase it more, more and more and more. Now yeah, it's warm enough, now it's too warm adjust it a bit down, the temperature down, down. That's perfect, and then now it's lunchtime I need to leave to the canteen, I would just switch it off then and then leave it here and hope that no one takes it. Yes, so now it's off.	L13 reaches for the fan and places the control unit on it. She puts it on the table to her left. She increases the temperature setting, then decreases it. She presses the on/off button on the control unit.
07:02	I	Okay thank you, and where would you place it on the desk or, like, if you were using the fan, how would you?	
02:12	L13	I guess that this one looks very portable, I would leave it on my desk or put it under on the floor, yeah. It's small enough. So, I put it anywhere around me. Just move it, because it's small but maybe it's very powerful so I don't have to move it. But, if I can I would move it down, and put it on the floor as well as the desk, just switch.	L13 picks up the fan and looks at it. She first places it around arm's length at about 45 degree on the table, then moves it under the desk.
07:49	I	Okay, thank you very much. So, this was the scenario and now the question, how useable and how useful did you find the device and the system? And do you have any suggestions for changes or alterations?	
08:13	L13	I'd definitely, it's useful because it gave me some warm and for me and you said that because you offered two interfaces for me I'd prefer because I try not to use and not, I'm not trying I just don't use mobile phone as, as an interface for controlling anything if there is an alternative that is more tangible. That is personal preference, yes so that's why you could see me bypassing them mobile phone interface and using that one because I feel that there is more direct interaction and direct control and, yeah, feedback compared to using that. I completely forgot I had that.	L13 points towards the app.
09:12	I	Okay, and the interface itself on the device that was useable?	
09:17	L13	Yes, yeah.	
09:18	I	Did you experience any problems?	
09:21	L13	Well, I understand that this a paper prototype and that's why I think that's a new change and give me the feedback immediately. But maybe with that light would be red at all time, can it change to be blue when the temperature goes down to what I don't know the threshold? I think that's it. Let me think.	L13 picks up the fan with the control unit and goes through the paper layers.
10:02		Yeah, I found maybe, okay, there is one benefit of having a phone interface so if I put this under	L13 puts the fan on the floor. She picks up the app prototype.

TC	ID	Conversation	Gestures
		the desk, now it's not in them, I feel I want to move it further to there, so now it's far from reaching easily. Now, I would prefer the mobile phone interface, the mobile phone app and I can adjust it from here because it's wireless connection.	
10:39		But if I put it here on my desk just on the chair behind the shelf, it's easy to reach and I prefer that direct interface, and I switch it off because I'm leaving my desk for lunch.	L13 picks up the fan from the floor and places it on the desk. She briefly points behind her back to the chair and an imaginary shelf. She then points towards the control unit.
11:07	I	Well thank you so much,	
11:10	L13	A pleasure.	
11:11	I	Yeah, this was this part, so I'll switch off the video camera and I have this questionnaire.	

Participant L14

TC	ID	Conversation	Gestures
00:02	I	Okay. So, the scenario we have is this one. So, it's a regular office day, and you've just come into the office from outside and you feel slightly hot from walking in the cold and coming into the warm office, and you've been given this personal heating cooling device to use. And now please talk us through how you would use it.	
00:28	L14	Which one, the phone or the ...?	L14 points towards the app and then the control unit.
00:30	I	So, this is the heating cooling source.	The interviewer points towards the control unit.
00:34	L14	Yeah.	
00:35	I	So, without this, the whole thing doesn't work. And it's up to you if you control it on the interface here or using the phone.	
00:43	L14	Okay.	
00:43	I	But you will have to attach it to something, either the fan or the wearable.	
00:50	L14	I think that ideally if I was coming in from the outside and wanting to adjust temperature, I think a wearable would be more suitable or more desirable. And I would probably control it with this as opposed to the phone.	L14 picks up the control unit.
01:13	I	Okay.	
01:14	L14	Am I understanding that correctly where you can adjust it with either one?	
01:19	I	Yeah. You can also use both. You can use one first and then the other. So, it's up to you. So, if you have both ... both are available.	

TC	ID	Conversation	Gestures
01:27	L14	Yeah. If I had to adjust it to a temperature where I didn't immediately know which temperature I wanted, I would use this, because I find this more intuitive.	L14 briefly lifts up the control unit she has been holding in her hands.
01:38		And with phone interfaces, when it shows you the ambient temperature, you start having to do some mental analysis and that's what I really don't like about a lot of these phone applications. They give you all of this information that it doesn't really matter.	L14 points towards the app prototype.
01:50		What I want to do is, I want to turn the cold up or, like, the heat up, or whatever on a continuous kind of scale. I don't want to have to think about, "Well, do I want 5 or 7 degrees?" It seems ridiculous.	L14 turns the pointer on the control unit.
02:05		So, I really like this, particularly. If it was on a wearable, that would be even better, because fans are super centralised, where if it could be a wearable, awesome.	L14 holds up the control unit. She briefly points towards the fan then the cloth.
02:17		And especially if you are coming in from outside, fans, there's noise, there's ... it causes ambient temperature changes, is it, am I only going to get cool on this side of my body and not that side of my body. So, a wearable would definitely be more desirable there, and I would certainly use this.	L14 first points towards the left side of her body then to the right side. She holds up the control unit.
02:37	I	Okay.	
02:38	L14	If, for example, there would be some indication of, I don't know, if it could suggest to me a temperature range, that would be even better. Because I know that the compulsion for people is when they're really, really hot, they just whack the cool all the way up to 100%, which, I mean, thermostats don't work like that, and we all know this, but we have that mental desire to do that.	L14 gesticulates with the control unit in her hand.
03:04		Or you come in and you're freezing and you're, "Oh my god, turn the heat up to 45", it's ridiculous, but we do that. And so, if it could suggest a temperature so I didn't have to take my best guess. If it could suggest a range or something like that, then that would be really useful.	L14 points towards the control unit interface.
03:20		But I prefer this instead of having to look at numbers which are essentially meaningless. If you're feeling with your body, this is much more intuitive than having to deal with numbers.	L14 puts the control unit on the table and then points towards the app.
03:32	I	Yes. That's true. So, could I ask you to just show me where you would put the device on your body in this scenario?	
03:43	L14	If I had, I don't know, a special work cardigan that was just for temperature control then I'd probably ... I think that I would have it down by	L14 picks up the cloth and wraps it around her shoulders. She places the control unit at the bottom of the cloth.

TC	ID	Conversation	Gestures
		the bottom. Down there. So, it's easily accessible with both of your hands.	
04:02		There's no distracting gestures or anything with people around you because that can be distracting if somebody's constantly ... it does need to be on the shoulder, it needs to be where you can see it. So, being on the bottom, even on the other side, so you could flip it over and adjust, I think would be really cool.	L14 briefly moves her hand towards her shoulder. She lifts up the corner of the cloth and moves the control unit from the outside to the inside.
04:20	I	Okay. Okay.	
04:21	L14	Is that enough? Is that clear?	L14 removes the cloth from around her shoulders.
04:22	I	Yes, that was very clear. Thank you. So, now imagine you're still wearing this, and now it's time for your lunch break. What would you do with the device in that case?	
04:35	L14	I'd probably forget about it.	
04:36	I	Okay.	
04:36	L14	To be honest. Unless I ... that's the thing, is that I know I'd forget about it. So, I don't know if it could sense that it had been taken off and turn itself off, or it could sense that it had been put on and activate.	L14 uses gestures to indicate taking off a wearable device and putting it on.
04:50		I think that battery saving mode would probably have to be inherent in the wearable because ... yeah, that kind of thing is the sort of thing that I just would not think about. I know myself, I wouldn't think about it.	
05:04	I	Okay. Okay. So, and then it's the afternoon, you're back to your workplace, and now you're feeling slightly cold because the temperature has gone down a bit, and so, what will you do with the device? Would you use it?	
05:23	L14	Yeah, yeah. If it was super useful for controlling my body temperature at work, absolutely I would wear it. I totally would. And I'd do the exact same thing. If it was in a convenient place, it would be a small adjustment.	L14 picks up the control unit and places it on her upper leg.
05:40	I	So, in this case you would use the heating mode?	
05:44	L14	If I was cold?	
05:45	I	Yeah.	
05:46	L14	Yeah. Or I would probably ... it depends on how cold I am. I would either turn down the coolness, or then turn it on to heating mode. It depends on, if I'm only slightly chilly and this is up to 11, I might turn it down a little bit.	L14 points towards the control unit.
06:01	I	Okay. Cool. So, and now it's the end of your working day, you're ready to go home, so what would you do with the device?	
06:12	L14	Take it off, and as I said, I think that if there was some way of sensing whether it was being worn or not, I think that would be really useful.	

TC	ID	Conversation	Gestures
		Because yeah, it's hard to remember to turn off a million devices. And I think we also expect devices to have some sort of power save mode, or some sort of inherent intelligence that it would understand what mode that it's in, because it's really hard to remember to manage devices. So, I think like some sort of inbuilt self-management would be really important.	
06:47	I	Okay. Yeah, that's great. Okay. Thank you so much. So, this was the scenario, and now the question, how usable and how useful did you find the device? And do you have any suggestions for alterations or changes?	
07:02	L14	I think that, as I said, I find this very intuitive. This is also speaking from my own values on interface design, but I do find a continuous scale much more human than numbers, because you look at your phone in the morning and you go, "Oh 11 degrees. Well, how cold is that? Well it's kind of cold but it's not really, and if I wear a heavy coat." It's hard to internalise what those numbers are.	L14 picks up the control unit.
07:32		If something like this could ... if you turned it on cold, like a cooling mode, and it could show you, maybe somewhere on the dial where you are now, and you are able to turn it a proportion away from that, where you are now. So, you can turn it to a proportion of change. That would be really useful. Or if you put on heating mode, it could tell you well, "Here's where the heating is, right now, how much do you want to change it?" I think that that would be really useful.	L14 indicates a position on the interface of the control unit. She runs along the interface with her finger.
07:59		Because I think that instead of numbers we, especially with continuous things like this, we deal with proportions.	L14 points on the app.
08:07	I	Okay.	
08:08	L14	And I think that would be really useful. With a phone... I think also being in-built especially for a wearable device or a fan, I would always want the control to be on the device because I've got enough crap on my phone. And if it's not something that I'm using like 3-5 times a day I won't put it or keep it on my phone. I just won't ... internal memory is precious.	L14 briefly holds up the control unit then points towards the app prototype. She picks up the control unit again and briefly places it on the cloth.
08:35		And so, this is something that I would definitely want inbuilt on the device because there's really ... unless you're controlling it from home where there's some reason to have it on your phone, like there's some distance or geography or something like that, then I would not want it on my phone, I'd definitely want it in-built.	

TC	ID	Conversation	Gestures
08:51	I	And, okay, thank you. And coming back to what you said previously with you're seeing the range or ... I forgot how you explained it.	
09:03	L14	The proportion?	
09:05	I	The proportion. That was it. Could you draw it, like visualising what you ... yeah, on one of these?	
09:12	L14	Yes. So, a swirl like that, and say I put it in cool mode, it could tell me, 'This is the temperature range you're operating in right now.' And I could go, "Oh, well, yeah, I definitely want to be cooler than that." And I could turn it to here. And then maybe this could travel and it could show me how close it is to that range, which I think would possibly counteract that desire to just whack it all the way up because, "Oh my god it's so hot", so you whack it all the way up to the maximum which is wasteful and completely countered to the way that these systems work, which I'm sure you know, and I find myself doing it even though I know it's the wrong thing to do, I still find myself doing it. So, if there was some way of knowing ... because I think the problem with a lot of temperature systems is there's no way to see system status. That knowing the status of the system you whack it all the way up to here because you're, "Oh, it will catch up faster and be super cool. So, when it's here, I might turn it off. Or when I feel it's kind of here, I might turn it off." But being able to see the responsiveness of the system might be really useful, and then if, I don't know, maybe this could be attached to the centre or something, and then when it moves to here I could be like, "Oh, okay, I'm there. Well, I'm actually too cold so maybe I'll turn it down a little bit." Or, "That's obviously not enough so I'll turn it up even more", but dealing with that proportion takes away the mental calculation of, "11.2 degrees, 14.6 degrees." They're meaningless numbers. It's all about, what do I feel and how close am I or far away am I from my ideal state of affairs. Is that clear?	L14 picks up an empty control interface layer and starts drawing.
11:17	I	Yeah, that's great. Yes. Well, thank you so much. Do you have any other comments, or that's it?	
11:23	L14	No, I think it's ...	
11:24	I	That was really well ...	
11:25	L14	I think it's really ... I really like this. I think it's really nice. It's satisfying to use, it's intuitive. This, I think, is really cool.	
11:32	I	Okay.	
11:32	L14	Yeah. I think it's great.	

TC	ID	Conversation	Gestures
11:34	I	Thank you so much. Okay. So, this is the part that I was going to record, so I will switch off the video camera at this point.	
11:42	L14	Sure.	

Participant L15

TC	ID	Conversation	Gestures
00:01	I	Okay, the scenario is the following one: it is a warm day outside and the sun is heating up your office. Opening the window doesn't provide relief. You have been again given this personal cooling device to use. Can you please talk us through how you would use it.	
00:18	L15	Okay, so I think... I mean, it depends... well, it probably ... no, I think kind of overall this seems more appealing, from what I can wear. With the fan I guess it might be ... it depends on how comfortable this clothing was and whether it was restricting but if it was a cloak and my arms were still free I would probably use that. But then equally...	L15 touches the cloth. She briefly points towards the fan. She touches the cloth. L15 briefly touches the fan.
00:44		Let's see. I guess if it's cold in my office I would probably put a scarf on so then that would be fine; but equally this is definitely appealing in that it is not just blowing and potentially blowing my paperwork around as a fan can do.	L15 picks up the cloth and arranges it around her neck and shoulders.
01:00		So I would probably opt for this, and I'm quite warm without. So I guess if I had this and this had to be on it, it might be easier for me to use my phone interface because otherwise, if I'm adjusting it, it's a little bit awkward to get to.	L15 points towards the cloth. She picks up the control unit and places it on her left shoulder, slightly on the upper arm.
01:20		But potentially I guess if I had it somewhere, that was resting, and then obviously I would switch it on and switch it to the cool setting. And I guess turn my dial up [pause] to see how it got and get on with my work.	L15 removes the control unit from her shoulder. She adds the cooling layer. She adjusts the setting to about 25%. She places the control unit at the end of the cloth resting it on the table.
01:50		I can see other things good about this is that depending on if it's a shared office and if there are other people there they might get annoyed by the noise of the fan going and throwing things around or you even might get envious whereas this is a little bit more inconspicuous. And sometimes there is tension in offices where some people were like: "don't open the window" or "do open the window" or if there is building noise outside then sometimes that would be [inaudible, 2:14] anyways.	
02:15		There is something quite nice and private and inconspicuous about this cloak, I would say.	L15 briefly touches the control unit before pointing on the app

TC	ID	Conversation	Gestures
		Depending on where it was I might find it easier, actually, to just use the smart-phone if it was handy to alter it. But there is something quite nice about the interface to kind of adjust the output or use the dial and adjust it the way you want.	prototype. She then picks up the control unit again and moves the dial slightly.
02:38	I	Okay. So after a while the temperature you originally set starts feeling a little bit too cold and you want to adjust it.	
02:51	L15	Okay. I would probably [sound of adjusting settings] ... that right back down to here and see how I go. Or, again, I guess I could reflect to my little... I would be like "okay I will lay down at whichever degrees" and then I guess I'd move right up the marker until I get up to there. Okay?	L15 adjusts the setting on the control unit to about 15%. She then focusses on the app and adds the cooling screen. She indicates adjusting the slider value towards the upper point of the scale.
03:17	I	Okay. So, now it's time for your lunch break. And you are planning to leave the office for lunch. What would you do with the device?	
03:25	L15	So, it's a sunny day and it's hot. So, I might want to just enjoy the weather. And I might feel a bit too hot, I guess, so I would want to go to just probably bring it along with me ... put it in my bag, go outside and enjoy the weather as it was, and still have the option of adjusting it out there. But I probably would want to just go and enjoy the breeze, or the sunshine.	L15 removes the cloth from around her neck and shoulder and imitates putting it in a bag.
03:50		But this could potentially be quite nice, having a portable cooling system when I was outside. Yeah. Something that I could like ... again this is kind of more appealing so I can bundle it up and put it in my bag and carry it with me if I need it.	L15 puts the cloth together, holds it up briefly and puts it in a pile on the desk.
04:03	I	Okay. Cool. So ... and then so you are back in your office. You have been working all afternoon and you are ready to go home. So, what would you do with the device in that case?	
04:17	L15	I would take it with, because if I was travelling on the Tube, especially on a hot day, besides a bottle of water it would be very nice to have a cooling system.	
04:27		So, if it was a day when I've cycled, I would probably wouldn't bother with it. I would leave it at the office. But otherwise I would probably put it on and get myself ready so that on the Tube I could have something to cool again, having this ...	L15 plays with the cloth on the table. She indicates wrapping it around her neck. She adjusts the dial on the control unit.
04:44		Well, as long as... if the phone app worked without any connection, or just Bluetooth or something, so I could use it underground. Again, I'd probably just do that because it's quite inconspicuous because most people are playing on their phones so I could just kind of, you	L15 reaches for the app.

TC	ID	Conversation	Gestures
		know, adjust it. Yeah. So I think it would be really useful, on the Tube or something like that.	
05:02	I	Okay. Well, thank you so much. So, this was the scenario. And now you've used it, how usable did you find it and how useful do you think it was? Do you have any suggestions for alterations?	
05:16	L15	Well, I think having the option of both interfaces is good because, you know, different scenarios require different things. I think having something that's maybe ... yeah, that pins onto a cloak but maybe looks kind of pretty. It looks like a badge but has the ability to, with a little dial on it ... could be quite nice. And it is nice having something that's doing something really practical but also something that's quite a beautiful accessory and provides adjustable heat.	L15 plays with the control unit.
05:52		It seems pretty usable to me. I really like the idea of something that's kind of soft that I can sew on like a cloak, and that I can carry around, portable, that can go in my bag along with everything else and be brought about.	L15 picks up the cloth and lifts it up. She puts it back down on the table.
06:08		I guess ... yeah ... I mean, it's hard to tell because it is obviously just a prototype, to imagine what ... but I like the idea of the kind of the spinning that's quite convenient that you've got that kind of level of control where you've got adjusting and feeling it.	L15 removes the control unit from the cloth.
06:20		This is useful too, but I think after then you just probably become more aware by looking and being like "oh, actually my favourite body temperature is 20", you know having a cooling device might be useful.	L15 picks up the app.
06:34		You probably get more aware of it but I imagine just this, something you sense would be fine. But, as you say, having this in some contexts, particularly like it might be easy if you're wearing it depending on where it is positioned, it might be easier to just use the phone.	L15 points towards the control unit. She points towards different places on her body, the shoulder, upper leg.
06:57		Did you think at any point of having it as that you didn't have to switch between hot and hold, that it's just sort of half hot and the other half is cold? Kind of like a shower setting? I don't know if that would be better or not, because it's one less click. But I guess you've ... it's nice if it makes it clear if you are in cooling zone or hot, which sometimes, especially with taps, I find when the markings have run off and you're kind of turning it and it being like: "Is it getting hotter? Yeah, yeah. I'm burning now." And then have to move back to colder. So actually it's maybe nice to keep them separate.	L15 picks up the control unit.
07:26	I	Okay.	

TC	ID	Conversation	Gestures
07:27	L15	Yeah.	
07:27	I	So, could you otherwise draw or visualise what you've ...	
07:34	L15	Well, I will probably use some of this fun, pretty paper. I guess, yes, finding some way [pause] to make [pause] something of a ... I'm not good at design so I can't do that [laughing]. But finding some way to make part of the design... the features of the functions be reflecting the design or something pretty that will show that we were heating up, or even just ... yeah, rather than say having a blue or orange thing it might be good to have a blue stripe or something... that is pretty and changes and the rest is just a fixed dial.	L15 picks up coloured paper.
08:24		I mean, in terms of the size obviously it depends if the whole kit can be made a little bit smaller. And maybe ... a soft circle would be good, because you could have ... it would be kind of lighter maybe, depending on the chip. And, yeah, I guess that's the other thing, if it's very heavy and it would drop down ... but you also want it to be resistant, and resistance from weather if you're going to be wearing it out and about.	L15 picks up the control unit.
08:53		You obviously want something pretty but proof. So either something really that was kind of like a brooch. But simple. I'm not very good at drawing, so I'm going to refrain. I'm always disappointing in these kind of scenarios. I did another one where they have plasticine and everything, and I was just like "stroke". Sketch here. But yeah.	
09:20	I	Okay.	
09:21	L15	Okay?	
09:21	I	That's fine. No worries.	
09:23	L15	[mutual friendly laughter].	
09:25	I	Yeah, not everyone wants to draw but that's fine.	
09:26	L15	Artistically inclined.	
09:28	I	Okay, well thank you so much. So, this was the part I was going to record, so I am going to switch off the video camera now.	

Appendix D

Materials User Study on Personal Heating Prototypes

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D.1. Information Sheet



Information Sheet

Research study "Microatmospheres: Personal Heating/Cooling Devices": Information for Participants

We would like to invite you to be part of this research project, in which we are looking at people's individual comfort in shared, open-plan work environments and at possibilities to improve it using personal heating and cooling devices. Please read the following information carefully before you decide to take part; this will tell you why the research is being done and what you will be asked to do if you take part. Please ask if there is anything that is not clear or if you would like more information.

If you do decide to take part you will be given this information sheet to keep and be asked to sign the attached consent form to say that you agree. You are still free to withdraw at any time and without giving a reason.

In the scope of this study we will present two prototypes to you and ask you to use them as you feel appropriate at your workplace. We will ask you to provide feedback on your use and the usability of the prototypes as well as on your thermal comfort throughout the test period.

This study is laid out as follows:

First, we will assess the overall conditions and your general comfort in your workplace. We will ask you to fill out a questionnaire, which will look at your experiences with and your perception of comfort in your workplace environment at the School of Electronic Engineering and Computer Science, Queen Mary University of London. This session will take about 10 to 15 minutes.

In addition, we will install sensor nodes at your workspace, which will take the following environmental readings: temperature, humidity, light levels, and air movement. The sensor nodes will stay installed throughout the study. As they are battery driven, we might have to access them every now and then for charging or will provide you with spare batteries.

Next, one of two heated prototypes will be given to you at a time, which you can use during your working day to improve your felt comfort. At the beginning we will briefly explain to you how the respective prototype works. You will have each device at your disposal for two working days.

During this time, we would like you to fill out a questionnaire four times a day, which asks about your feeling of comfort "right now". Ideally this would happen 15 minutes after you have arrived in the office, about two hours afterwards or before you go for your lunch break, in the middle of the afternoon, and at the end of your working day, i.e. before you leave. Also, we would like to ask you to put down in the comment section of the questionnaire any particular changes in perception, adaptive behaviours, or changes of comfort or discomfort you become aware of in

relation to environmental temperature, other people's actions or devices, any personal devices you use or your use of them. We will ask you to report on your comfort in this way on each working day of the study.

At the end of the test period for a device, we would like to ask you to reflect on your use of and satisfaction with the device and fill out a very brief evaluation questionnaire.

To conclude the study, you will be given both prototypes for use during another two working days. We will ask you also to fill out right now comfort questionnaires four times a day as described previously. After the two working days with both prototypes, we will conduct a brief interview about your experiences with our prototypes. The interview will be video recorded.

The video recording will be transcribed and is for documentation and analysis purposes only. Please let us know if you do not feel comfortable to be recorded. If you have any questions, please let us know. If any questions should come up during the study, please do not hesitate to approach us.

All the information we collect about you during the course of the research will be kept strictly confidential. You will not be able to be identified in any reports or publications.

The audio and video recording of the session as well as any pictures taken of you will be used for analysis purposes only. No other use will be made of it without your written permission, and no one outside the project will be allowed access to the original recordings.

It is entirely up to you to decide whether or not to take part. There are no disadvantages attached if, at any time, you choose not to take part or decide to withdraw from the study.

If you have any questions or concerns about the manner in which the study was conducted please, in the first instance, contact the researcher responsible for the study, Katja Knecht, on k.knecht@qmul.ac.uk or by phone: 07415 714788

If this is unsuccessful, or not appropriate, please contact the Secretary at the Queen Mary Ethics of Research Committee, Room W117, Queen's Building, Mile End Campus, Mile End Road, London or research-ethics@qmul.ac.uk.

D.2. Questionnaires

Thermal Comfort Assessment Questionnaire

In the following questionnaire we would like to get to know how comfortable you feel and how satisfied you are with different indoor environmental parameters at your workplace at QM. In addition, we would like to get to know about your individual thermal background and preferences, what you usually do to achieve thermal comfort at home and in the office.

Section 1: Background Information

1.1. What is your age?

1.2. What is your gender?

Female

Male

1.3. Which of the following best describes your workspace?

Cubicle with high partitions (about 1.5m high)

Cubicle with low partitions (lower than 1.5m high)

Desk space in an open-plan office

Other, please describe:

1.4. How many people do you share your office with?

1.5. For how many months or years have you been working in your current office?

1.6. How many days a week are you usually working in your office at QM?

1.7. How much time do you spend on average at your desk when you are in?

Section 2: Workplace Satisfaction

On a scale from 1 (very dissatisfied) to 7 (very satisfied), please let us know how satisfied you are with the following aspects of your work space:

		Very Dissatisfied		Neutral			Very Satisfied		Does not apply
		1	2	3	4	5	6	7	
2.1.	The amount of space available for individual work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.2.	The level of visual privacy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.3.	The ease of interaction with colleagues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.4.	The comfort of the workspace furnishings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.5.	The temperature	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.6.	The level of personal control over your local thermal environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.7.	The air quality (i.e. stuffy/stale air, cleanliness, odours)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.8.	The level of personal control over the indoor air quality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.9.	The amount of light	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.10.	The visual comfort of the lighting (e.g., glare reflections, contrast)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.11.	The level of personal control over the lighting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.12.	The noise level	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.13.	The sound privacy (e.g. ability to have conversations without your neighbours overhearing & vice versa)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.14.	The cleanliness of the workspace	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>

2.15. All things considered, how satisfied are you with your workspace?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

2.16. Please estimate how much you think your productivity is increased or decreased by the environmental conditions in this building (e.g. thermal, lighting, acoustics, cleanliness):

Decreased Increased

-20% -10% -5% 0% +5% +10% +20%

2.17. If you have any comments regarding your satisfaction with specific workplace parameters or your overall comfort, please let us know.

Section 3: Thermal Comfort

3.1. Which of the following can you personally adjust or control in your workspace? (Please check all that apply. In case any of the devices are your own and not provided by the department, please indicate.)

- Operable window
- Window blinds or shades
- Thermostat
- Portable heater
- Permanent heater
- Room air-conditioning unit
- Portable fan
- Adjustable air vent in wall or ceiling
- Adjustable floor air vent (diffuser)
- Door to interior space
- Door to exterior space
- None of the above
- Other, please describe: _____

a If you are dissatisfied with the level of personal control, what would you wish for?

3.2. How is the temperature in your workspace controlled and who decides?

3.3. In case you are dissatisfied with the workplace temperature, which of the following contribute to your dissatisfaction?

a In cool/cold weather, the temperature in my workspace is: (Please check all that apply)

- Often too hot
- Often too cold
- I have not experienced a cold period in this room yet

b In cool/cold weather... (Please check all that apply)

- My hands are too cold
- My feet are too cold
- Other, please describe: _____

c When is this most often a problem? (Please check all that apply)

- Morning (before 11am)
- Mid-day (11am – 2pm)
- Afternoon (2pm – 5pm)
- Evening (after 5pm)
- Weekends/holidays
- Monday mornings
- No particular time
- Other, please describe: _____

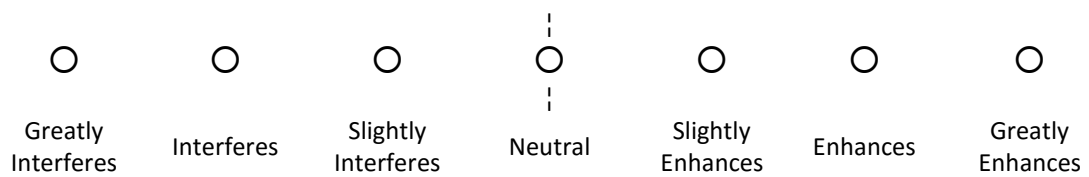
d How would you best describe the source of this discomfort? (Please check all that apply)

- Air movement too high (draughty)
- Air movement too low (stuffy)
- Drafts from windows
- Drafts from vents
- Drafts falling from the ceiling
- Heat from office equipment
- Heating/cooling system does not respond quickly enough to the thermostat
- Hot/cold floor surfaces

- Hot/cold ceiling surfaces
- Hot/cold wall surfaces
- Hot/cold window surfaces
- Humidity too high (damp)
- Humidity too low (dry)
- Incoming sun
- My area is hotter than other areas
- My area is colder than other areas
- Thermostat is inaccessible
- Thermostat is adjusted by other people
- Other, please describe: _____

e Please describe any other issues related to being too hot or too cold in your workspace

3.4. Overall, does your thermal comfort in your workspace enhance or interfere with your ability to get your work done?



Section 4: Individual Thermal Comfort and Behavioural Adjustments

4.1. Would you call yourself a person who easily feels cold, or easily feels too warm, or neither?

4.2. What do you do or how do you adjust to the temperature in the office **if you feel cold?** *(If applicable, please let us know briefly which devices you use, if you put on/off specific items of clothing, if you make adjustments to the environment, or if you aware of any other behavioural adjustments)*

4.3. What do you do or how do you adjust to the temperature in the office **if you feel hot**? *(If applicable, please let us know briefly which devices you use, if you put on/off specific items of clothing, if you make adjustments to the environment, or if you aware of any other behavioural adjustments)*

4.4. From your point of view, what is the greatest challenge you face in achieving thermal comfort in your workplace?

Thank you very much for your participation!

Right Now Thermal Comfort Survey

The following questions refer to the current conditions and the level of comfort as you perceive it at the time you answer this questionnaire. Please reply accordingly and tell us how you feel right now.

Date: _____ Room: _____

Time am am pm pm

1. How would you describe the weather outside?

Clear/sunny				
Partly cloudy				
Cloudy/Grey				
Drizzly				
Rainy				
Snowy				
Other (please specify)				

2. How do you feel right now?

Cold				
Cool				
Slightly Cool				
Neutral				
Slightly Warm				
Warm				
Hot				

3. Would you like to be

Much cooler				
A bit cooler				
No change				
A bit warmer				
Much warmer				

4. How acceptable is the room temperature to you?

Very unacceptable				
Unacceptable				
Slightly unacceptable				
Neutral				
Slightly acceptable				
Acceptable				
Very acceptable				

Time am am pm pm

5. If you are dissatisfied, how would you best describe the source of your discomfort?

Air movement too high / too low				
Incoming sun				
Drafts from windows / vents				
Hot surrounding surfaces (floor, ceiling, walls)				
Cold surrounding surfaces (floor, ceiling, walls)				
Heating system provides too much heating				
Heating system provides not enough heating				
Personal device provides too much heating				
Personal device provides not enough heating				
Other (please specify)				

6. Please indicate which of the following layers of clothing you are wearing right now:

Short sleeved shirt/top				
Long sleeved shirt/top				
Vest				
Trousers/long skirt				
Shorts/short skirt				
Dress				
Jumper/Cardigan/Sweatshirt				
Jacket				
Tights/Legging				
Long socks				
Short socks				
Boots				
Shoes				
Sandals				
Scarf/shawl				
Hat/cap				
Other (please specify)				

7. How would you describe your activity level in the 15 minutes prior to completing this survey?

Seated (passive, relaxed; e.g. reading)				
Seated (active, working; e.g. typing)				
Standing (passive, relaxed)				
Standing (active, working)				
Walking (indoors)				
Walking (outdoors)				
Other (please specify)				

Time am am pm pm

8. If you ate or drank anything in the 15 minutes prior to completing this survey, what temperature was it at?

Cold				
Room Temperature				
Hot				

9. Please let us know about the following states of environmental controls in your office, close to your workplace: (please tick if appropriate)

Door open				
Window(s) open				
Blinds/curtains down				
Lights on				
Air condition on				
Room Heating on				
Fan on				
Heater on				
Other (please specify)				

10. Did you actively change any of the following? (Please circle or underline which applies)

Item of Clothing	on / off	on / off	on / off	on / off
Heating	up / down	up / down	up / down	up / down
Fan	up / down	up / down	up / down	up / down
Prototype	on / off	on / off	on / off	on / off
Window(s)	open / close	open / close	open / close	open / close

11. If so, what was your reason for doing so?

I felt hot				
I felt warm				
I felt cool				
I felt cold				
Other (please specify)				

12. If you have any additional comments, please let us know:

Study Evaluation Questionnaire

In the following questionnaire we would like to hear about your use of our prototypes during the past two working days. We would like to know how satisfied and comfortable you were using them and if they made a difference to your thermal comfort.

Portable Prototype

1. Did you use the portable prototype?

- Yes (more than one day)
- I started but stopped using it
- No

2. When and how often did you approximately use it? (Please let us know, for example, if there were specific times or occasions you used it. If you did not use it or started but stopped using it, please let us know why.)

3. Please describe any **advantages and benefits** of the prototype, which you encountered:

4. Please describe any **limitations and short comings** of the prototype, which you encountered:

5. Did the portable prototype interfere with your work? If so, please let us know in what way.

6. Did having the portable prototype have an impact on your feeling of control over your local thermal environment? Please rate on a scale from 1 (very much decreased) to 7 (very much increased) my feeling of control over the local thermal environment.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very much decreased	Decreased	Slightly Decreased	No change	Slightly Increased	Increased	Very much increased

7. Did having the portable prototype have an impact on your perceived thermal comfort? Please rate on a scale from 1 (very much decreased) to 7 (very much increased) my perceived thermal comfort.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very much decreased	Decreased	Slightly Decreased	No change	Slightly Increased	Increased	Very much increased

On a scale from 1 (very dissatisfied) to 7 (very satisfied), please let us know how satisfied you were with the following aspects of the portable prototype:

	1	2	3	4	5	6	7
8. The amount of heat it provided	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. The temperature control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. The portability of the device	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11. The flexibility of use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12. The usability in your workplace setting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13. The effectiveness of providing thermal comfort	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14. The intrusiveness of the device	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

15. Do you have any suggestions for alterations in regard to how the device works and how it is controlled? If so, please let us know.

Prototype Evaluation Questionnaire

In the following questionnaire we would like to hear about your use of our prototypes during the past two working days. We would like to know how satisfied and comfortable you were using them and if they made a difference to your thermal comfort.

Wearable Prototype

1. Did you use the wearable prototype?

- Yes (more than one day)
- I started but stopped using it
- No

2. When and how often did you approximately use it? (Please let us know, for example, if there were specific times or occasions you used it. If you did not use it or started but stopped using it, please let us know why.)

3. Please describe any **advantages and benefits** of the prototype, which you encountered:

4. Please describe any **limitations and short comings** of the prototype, which you encountered:

5. Did the wearable prototype interfere with your work? If so, please let us also know in what way.

6. Did having the wearable prototype have an impact on your feeling of control over your local thermal environment? Please rate on a scale from 1 (very much decreased) to 7 (very much increased) my feeling of control over the local thermal environment.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very much decreased	Decreased	Slightly Decreased	No change	Slightly Increased	Increased	Very much increased

7. Did having the wearable prototype have an impact on your perceived thermal comfort? Please rate on a scale from 1 (very much decreased) to 7 (very much increased) my perceived thermal comfort.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very much decreased	Decreased	Slightly Decreased	No change	Slightly Increased	Increased	Very much increased

On a scale from 1 (very dissatisfied) to 7 (very satisfied), please let us know how satisfied you were with the following aspects of the wearable prototype:

		Very Dissatisfied	Neutral			Very Satisfied		
		1	2	3	4	5	6	7
8.	The amount of heat it provided	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9.	The temperature control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10.	The wearability the device	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11.	The flexibility of use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12.	The usability in your workplace setting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13.	The effectiveness of providing thermal comfort	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14.	The intrusiveness of the device	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

15. Do you have any suggestions for alterations in regard to how the device works and how it is controlled? If so, please let us know.

D.3. Interview Transcripts

Participant A1

TC	ID	Conversation	Gestures
00:04	I	So first of all, thank you for testing my prototypes. So, I gave you two different ones and, um, I would like to ask how you used them. So, if we could start with this one first.	
00:17	A1	Okay.	I hands the portable prototype to the participant; A1 gets up and takes it.
00:20		Um... I really liked this one, by the way.	A1 sits back down and places the portable prototype across the lap; A1 pats it;
00:26		Um, yes. Mainly...	A1 lifts portable prototype up and holds it between both hands
00:29		So, the first time I used it, I used it in my back. So, I put it here. Um, which was really nice because I really like this heat in my, in my back. Especially I really like um, I don't know do you call it contact heat,	A1 leans forward and places the portable prototype with the right hand across the lower back.
00:44		when you have a heat source contacting with your skin. I really find this very comfortable. So, I used it in my back, which was really, really nice.	A1 puts the portable prototype back on her lap and pats it.
00:52		Um, yeah, but it got a little bit uncomfortable after a couple of ... yeah, after a while cause I sat in my chair, I sat quite at the front, you know, so it got a bit uncomfortable.	A1 rests her right hand on portable prototype while gesticulating with the left and pointing towards the lower back.
01:08		Um, the other day I tried it to use it like this.	A1 takes both hands up and then grasp the portable prototype with both hands first at the sides and then pushes it towards the belly wrapping the hands around it.
01:11		So, the desk is here, and I used it for my belly and I also really, really liked it. Um, yeah.	A1 indicates the position of the desk surface, which comes to about mid-height of the portable prototype.
01:19	I	Okay.	
01:20	A1	So that's how I used it. And mainly when I, yeah, just when I felt like using it, so I really hadn't had a specific pattern. Usually in the morning, I am warmer, so I feel warmer. So around lunch time after lunch usually I get a bit cold, slightly, so I ... I used it after.	A1 gestures with both hands, which come to rest on top of the portable prototype still placed on the lap in between.
01:44	I	Okay, cool. Okay, thank you. And then, um, I gave you the other one.	A1 takes up the portable prototype and the battery that is attached and hands it to I.
01:54		So...	I puts the portable prototype down and takes up the wearable prototype and hands it to A1.
01:55			A1 takes the wearable prototype, puts it on the lap, and starts rearranging the folds;
01:57	A1	Um. So, the first time I also used it in my back. So, I took it, ah, I put it over my shoulders like that and sat there. Um... yeah, shall I also talk a bit about how, how it felt?	A1 takes up the wearable prototype by two of its corners up towards face height so it hangs in front of her; then she slowly throws it over her shoulders so that it covers her upper back and shoulders, rearranging the two corners,

TC	ID	Conversation	Gestures
00:04	I	So first of all, thank you for testing my prototypes. So, I gave you two different ones and, um, I would like to ask how you used them. So, if we could start with this one first.	
00:17	A1	Okay.	I hands the portable prototype to the participant; A1 gets up and takes it.
00:20		Um... I really liked this one, by the way.	A1 sits back down and places the portable prototype across the lap; A1 pats it;
00:26		Um, yes. Mainly...	A1 lifts portable prototype up and holds it between both hands
00:29		So, the first time I used it, I used it in my back. So, I put it here. Um, which was really nice because I really like this heat in my, in my back. Especially I really like um, I don't know do you call it contact heat,	A1 leans forward and places the portable prototype with the right hand across the lower back.
			which now rest on her chest so that the edges come down in parallel from the neck.
02:12	I	Yes.	
02:13	A1	Okay, so... yeah, again, I really liked the heat in my back. The only thing, which was a bit, um, it was a bit harder to handle than the, um, cushion because it's, um,	A1 gesticulates with her hands
02:25		with the wires and everything it was dragging it a bit down, so I had to adjust it a bit. So, it wasn't really as easy to use as this one.	A1 takes up the two corners of the wearable prototype resting on the chest, lifts the wearable prototype up a bit, and moves the upper part resting on her shoulders from right to left;
02:36		Um... so the second time I used it I tried it on my lap, which was also really nice because it warmed, um, my legs and um... it was easier with the cables cause I just put the ... um... the battery on the table or in my drawer and then I just put it over the lap. So, it was a bit easier than over the back.	A1 lifts up the wearable prototype from her shoulders, brings it back to the front, and arranges it over her lap so that the edges fall over her knees and to the side. A1 gesticulates with her hands and arms;
03:01	I	Okay, cool. And, um, when you had both of them available to you, which one did you use or did you?	I hands the portable prototype to A1; A1 receives it while the wearable prototype is still resting on her lap.
03:09	A1	Um... so I used this a bit more often because I just... yeah...	A1 places the portable prototype across her lap on top of the wearable one and pats it;
03:18		I liked it more and it's also I really liked that it's very, um, fluffy and easy to use.	A1 takes up the portable prototype, moves it between both hands and squeezes it;
03:23		You can just put it there or in the back. So, um, I used this one more often than the, um, scarf.	A1 places the portable prototype back on her lap, then moves it towards her back, and then puts it back onto her lap patting it and then indicating towards and patting the wearable prototype briefly
03:32	I	Okay. And, um, yeah, how did you choose. So, you switched between the devices? Or...	
03:40	A1	Yeah, yeah. I switched because I wanted to try both. So, um, I remember yesterday,	
03:46		I had this one on my lap after you brought me the battery. So, I tried this one again. Um, over the lap and, um	A1 lifts up the portable prototype from her lap with her right hand, and indicates towards and touches the wearable prototype with her left; slowly puts the portable prototype back down on her lap and rests her hands on it;

TC	ID	Conversation	Gestures
00:04	I	So first of all, thank you for testing my prototypes. So, I gave you two different ones and, um, I would like to ask how you used them. So, if we could start with this one first.	
00:17	A1	Okay.	I hands the portable prototype to the participant; A1 gets up and takes it.
00:20		Um... I really liked this one, by the way.	A1 sits back down and places the portable prototype across the lap; A1 pats it;
00:26		Um, yes. Mainly...	A1 lifts portable prototype up and holds it between both hands
00:29		So, the first time I used it, I used it in my back. So, I put it here. Um, which was really nice because I really like this heat in my, in my back. Especially I really like um, I don't know do you call it contact heat,	A1 leans forward and places the portable prototype with the right hand across the lower back.
03:57		then I also used this one, again, cause I really like it that I can just put it there and here is the desk and it is just so really comfortable.	A1 takes up the portable prototype with both hands, places it back down on and across her lap and pulls it towards her belly; A1 then indicates towards an imaginary desk in front;
04:06	I	Okay. Yeah, so um, you could only use one at a time but if you could have would you, would you have used both of them, together, or?	A1 rests her hands on the portable prototype
04:19	A1	Um, I, maybe not that often because one is really enough.	A1 grabs the portable prototype and rolls it slightly towards her upper body;
04:28		So, if it would be really cold, so if I would feel really cold in the office maybe I would use this one	A1 takes up her hands and gestures towards her upper body and shoulders; then indicates towards and touches the wearable prototype on her upper leg;
04:34		over the back because it has a larger area	A1 makes a wrapping movement with both of her hands and draws a rectangle in the air
04:36		than this one.	A1 places both of her hands on the portable prototype on her lap;
04:39		And use this one like this because I really loved having this to warm the belly. Yeah.	A1 grabs the portable prototype and pulls it towards her belly;
04:48	I	Okay, sounds good.	
04:49	A1	Yeah. But usually I would prefer this one. If it was just one.	A1 lifts up the portable prototype with her right hand turning it by 90 degrees in front of her upper body and squeezing it slightly with both hands; A1 puts the portable prototype back down across her lap and puts her hands-on top of it.
04:54	I	Okay, sounds good. Um, actually two more questions. So, one is, um, you also said in your questionnaire you have a heat pad on your seat,	
05:06	A1	Yes.	
05:06	I	on your chair. So, um, how would that compare with any of the two, those two prototypes?	
05:15	A1	Yeah. Um. Yeah, I have a heat pad. I, I still used it sometimes during the study. But since it was also a bit warmer and I had the prototypes I didn't use it as often as before.	A1 starts gesturing with her hands and puts them back down onto the portable prototype

TC	ID	Conversation	Gestures
00:04	I	So first of all, thank you for testing my prototypes. So, I gave you two different ones and, um, I would like to ask how you used them. So, if we could start with this one first.	
00:17	A1	Okay.	I hands the portable prototype to the participant; A1 gets up and takes it.
00:20		Um... I really liked this one, by the way.	A1 sits back down and places the portable prototype across the lap; A1 pats it;
00:26		Um, yes. Mainly...	A1 lifts portable prototype up and holds it between both hands
00:29		So, the first time I used it, I used it in my back. So, I put it here. Um, which was really nice because I really like this heat in my, in my back. Especially I really like um, I don't know do you call it contact heat,	A1 leans forward and places the portable prototype with the right hand across the lower back.
05:28		Um, the thing with the heat pad, I really like it, yeah, to sit a bit warmer and, um... yeah, but it is not so flexible, so I couldn't put it in my, in my back because it is really,	A1 gestures with her hands, rest them on the portable prototype and eventually points towards her lower back with her left hand
05:43		like it's not as good as this one cause this is really light-weight and flexible, so I can just put it over my back.	A1 puts her right hand on the portable prototype and grabs the wearable prototype with her left and shakes it. A1 lets go of both and moves her hands up imitating a throw movement over her shoulders
05:51		I couldn't do that with the heat pad cause it's, um, like this big and has a cable and it's attached to the socket... So, it's, yeah, I couldn't use it in my back, so I can just sit on it. I also, um... yeah, maybe I could put it on my lap, but then... Yeah. At the moment it annoys me even a bit because it is plugged in the socket and then I have the cable around the desk and, um, sometimes I roll over the cable with my chair, which is a bit annoying.	A1 outlines the size of the heat pad in the air in front of her and gesticulates in emphasis of her points.
06:27		So, I really like that these are... without a socket so I can put the battery where I want where it's most convenient, so I don't fall over it or anything.	A1 puts her hands on the portable prototype and gesticulates again to imitate actions
06:41	I	Thank you, that's great. And, um, the last question is because you also said in your questionnaire that, um, you had been thinking about taking, I think it was this one, with you	A1 lifts the portable prototype off her lap
06:56	A1	Yeah [laughing]	
06:56	I	when you were doing, when you were supposed to do your TA work in another building. So, um, what made you decide not to take it, or?	
07:07	A1	Ah, first of all, I wasn't sure if I'm allowed to cause this are study devices [laughing] so I was a bit, ah, unsure about that.	A1 pats the portable prototype; holds her hands up in front of her, and places them back down on the portable prototype
07:19		And, um, the second thing is, um... yeah, it is also really cause they are study devices, so I am really careful with them and I don't know in a TA environment maybe, I don't	A1 is gesturing with her hands and let them finally rest on the prototype again.

TC	ID	Conversation	Gestures
00:04	I	So first of all, thank you for testing my prototypes. So, I gave you two different ones and, um, I would like to ask how you used them. So, if we could start with this one first.	
00:17	A1	Okay.	I hands the portable prototype to the participant; A1 gets up and takes it.
00:20		Um... I really liked this one, by the way.	A1 sits back down and places the portable prototype across the lap; A1 pats it;
00:26		Um, yes. Mainly...	A1 lifts portable prototype up and holds it between both hands
00:29		So, the first time I used it, I used it in my back. So, I put it here. Um, which was really nice because I really like this heat in my, in my back. Especially I really like um, I don't know do you call it contact heat, know, what could have happened, but I was a bit careful about, too, not to. So that was why I did not take it.	A1 leans forward and places the portable prototype with the right hand across the lower back.
07:43	I	Okay. But you would have liked to take it, or?	
07:48	A1	Yeah, actually I would have liked to take it. Another thing, which would, maybe, um, yeah, ah, the cabling. So, this is a social, or I don't know, a social thing. But if it would have looked, um... awkward or odd if I would have taken it with me.	A1 points towards the battery and control lying next to her and continues gesturing
08:07		So that's the thing. If, um, if it would maybe without the cables and just a black cushion but then it would be easier to take it somewhere	A1 rests her hands on the portable prototype, turns her head and gazes down on the cables; A1 grasps and lifts up the controller and places it back down; A1 gestures, including the portable prototype in her gesture;
08:16		cause it's not looking like something strange people have not seen before. Maybe that is also something. Um... yeah.	A1 continues gesturing resting her hand on the portable prototype;
08:30	I	Okay. Thank you. It is really kind, thank you. So, yeah, that was all the questions I had. So, thank you very much.	

Participant A2

TC	ID	Conversation	Gestures
00:05	I	So first of all, thank you for testing my prototypes. I have some questions -	A2 holds the portable prototype in her arms, across her belly, legs crossed. She puts the battery on the table next to her, to her left.
00:10	A2	Thank you. It is nice.	A2 keeps holding the portable prototype in her arms.
00:12	I	I am glad you say that. So, I have a few questions about your use of them. And I would like to start asking you like how did you use them? For example, the cushion.	A2 strokes the portable prototype with her left thumb.
00:26	A2	The cushion. Oh, did you read the last -	A2 turns in her chair and reaches towards the folder with the questionnaires with her left

TC	ID	Conversation	Gestures
			hand, lifts them up briefly and puts them back.
00:30	I	No...	
00:30	A2	bits before? No, okay.	
00:31	I	No, um...	A2 turns back to front holding the portable prototype against her belly with the left and right hand.
00:32	A2	Okay. So okay, um, the blanket, for example, or scarf, um, I put it on my lap.	A2 turns again and reaches towards the wearable prototype, which is lying on her desk, slightly behind her. She holds the fabric between the fingers of her left hand while holding the portable prototype across her belly with the right. She turns back, holds both her hands briefly, fingers stretched out, in mid-air, the portable prototype now resting on her left upper leg. She then places both hands on her upper legs and moves them to the outside before placing her hands back on her legs.
00:41	I	Can you show me?	A2 nods and unfolds her legs.
00:43	A2	Yes.	A2 turns towards the table on her left, lifts up the portable prototype with her right hand, the battery with her left, and puts it on the table.
00:48		So, I was here at my desk and	A2 picks up the wearable prototype and unfolds it in its length as she turns slightly back again so that she is facing her desk. She unfolds the wearable prototype to its full size and puts it over her upper legs, so it falls down the sides of her legs and over her knees.
00:52		I put it with the circuit on the top.	A2 pats the sensing circuit briefly, which rests on her right upper leg, and makes a movement towards her upper body with her right hand. She continues holding the wearable prototype with her left hand.
00:55		Just because I did not want to damage it or drop it. I don't know.	A2 lifts up the wearable prototype briefly and places it higher up her upper legs. She then moves closer towards her desk with her chair. She looks at the sensing circuit and rearranges the folds around it.
01:02		I know that they are quite stable but because I saw the antenna on the XBee on this one then I was afraid that it would get like smashed or maybe...	A2 puts her right hand under the sensing circuit of the wearable prototype and lifts it up. She points with her left hand towards the XBee and along its antenna. She places the sensing circuit back down on her leg and then indicates towards her knees with her hands.
01:13		I don't know how fragile this is because I haven't used it, so I was afraid to... I left it on the top because I was afraid to smash it maybe with the drawer.	A2 points towards the XBee on her leg with her left hand and briefly touches it. She hovers both her hands over it briefly and then moves them both towards her knees. She hovers with both hands again over the sensing circuit and then moves them towards the knees, indicating with her right hand towards the drawers on her right.
01:21		Um...	A2 picks up the portable prototype and the battery on her desk, rearranges it and puts it back down.

TC	ID	Conversation	Gestures
01:26		So, I just had it like this on my lap while I was working.	A2 leans back slightly in her chair and indicates with both hands towards the wearable prototype on her lap. She moves closer to her desk with her chair, puts up her hands in mid-air over her keyboard and makes a typing movement with the fingers of her hands.
01:28		I did try as well to put it around me, like wrap myself with it. But then there was a problem with the battery.	A2 moves back with her chair and picks up the wearable prototype and holds it up in front of her. She makes a movement towards her back and shoulders with it but keeps holding it up in front of her. She reaches towards the battery and puts her right hand on it, while still holding the wearable prototype with her left.
01:38		Um... I switch this off.	A2 moves closer to her desk again and switches off the controller connected to the portable prototype, which was switched on.
01:49		But it is not that there was a problem with the battery, it is just that because I, basically, I kept the battery on the table...	A2 disconnects the control from the portable prototype and holds its end in her right hand. She touches the battery on the table with her left hand. She switches off the battery.
02:02		When I could not find that the cable was long enough for me to put it around me. So, I was conscious, I was afraid to drop it.	A2 connects the controller to the wearable prototype. She holds up the prototype with her left hand over her head and makes a slight movement towards her shoulders but then lowers the wearable prototype. She holds the wearable prototype in her right hand while reaching towards the battery on the table with her left.
02:13			A2 then lifts up the wearable prototype briefly with her right hand and then starts arranging it between both hands, by first folding it, then holding it unfolded in front of her upper body and turning it, so the cable is situated at the lower right corner. She then lifts up her left hand and puts the wearable prototype over her shoulders, so it falls down her back, the cable falling down on her right side.
02:33		I don't know. I found that if I was moving I was afraid to drop it, or I kept it like here: on my side, at the back of the chair.	A2 rearranges the folds of the wearable prototype over her shoulders and slightly sits back in her chair. She picks up the battery from the table and places it next to her at the back of the chair.
02:42		But then again when I moved... I don't know, I was always afraid to drop the battery on the floor and maybe to pull the cable	A2 turns her upper body back to front, facing the desk, and arranges the folds of the wearable prototype over her shoulders. She turns her upper body around and reaches towards the battery at the back of the chair with her right hand. She holds the battery in her hand and moves it off the chair before placing it back on again. She makes a pulling movement in mid-air with both hands.
02:51	I	Uh-um.	
02:52	A2	and I was obviously afraid that I couldn't see, see the circuit.	A2 reaches towards the wearable prototype at her back with her right hand.

TC	ID	Conversation	Gestures
02:56		So, if I would lean with my back on the chair maybe I would squash it. Or I was afraid to damage it.	A2 leans back with her upper body against the backrest, touching it only with her shoulders. She touches the wearable prototype with her right hand. She sits up straight and reaches for the wearable prototype at her shoulders.
03:03	I	Okay.	
03:03	A2	Um... But I did like the idea, though, of wrapping the, the blanket around me or any way of having it on me.	A2 picks up the wearable prototype by the ends falling over her shoulders, lifts it slightly off her back and puts it back, wrapping it around her shoulders and pulling its end together in the front. She lets go of the ends, so they fall over her shoulders and briefly touches her upper legs with her hands. She then takes up the wearable prototype again and starts pulling it off her back and shoulders with both hands.
03:13		So most of it I used it ... you see ...	A2 holds the wearable prototype up at the right side of the body. She reaches for the battery on the seat with her right hand, which she catches sliding down the seat. Brings the wearable prototype and the battery to the front.
03:22		I just kept the battery there and I... had the blanket on me. Yeah.	A2 places the battery on the table in front of her. She moves her chair back and puts the wearable prototype on her upper legs.
03:29	I	Okay.	
03:29	A2	The pillow instead ...	A2 disconnects the control from the wearable prototype and puts it on the table. She folds up the wearable prototype on her lap and puts it on the table, to her left.
03:42		Well, the pillow, again, I kept it on my lap.	A2 picks up the portable prototype with both hands. She sits back on her chair and places the portable prototype across her lap. She moves forward, towards the desk, with her chair and puts both hands on the portable prototype, slightly pulling it closer towards her upper body.
03:46		Um, I realised after I started using it that um...	A2 reaches for the cable of the control and connects it to the portable prototype. She switches on the battery.
03:52		the heat was only from one side, just from the top not from the bottom.	A2 turns slightly with her chair towards the interviewer and touches the heating area of the portable prototype with her left hand. Her right hand joins so both hands come to rest on the portable prototype briefly. She then lifts the forward-facing side of portable prototype up and touches the back of the portable prototype with her right hand. She puts it back down.
03:57		So, then I kept turning it if I wanted to have the heat a bit more on my lap.	A2 lifts up the portable prototype and turns it so the heated side touches her upper legs. She touches her left upper leg below where the prototype is sitting with her left hand.
04:04		Um, but I actually did like that, I always get like cold hands, so I did like just rest my hands on it.	A2 lifts up both hands and rubs the hands together. She briefly holds her hands over the

TC	ID	Conversation	Gestures
			portable prototype, fingers spread, and then places the left hand on the prototype.
04:11		So, I would twist it, turn it and just rest my hands on it.	A2 turns the portable prototype so the heated side faces up. She puts both hands on it briefly, lifts them up again, and places them back down, holding it and turning her chair towards her desk.
04:16		So especially if I was reading something rather than typing.	A2 points with her right hand towards her screen, while keeping her left hand on the portable prototype. She then lifts up both hands and makes a typing gesture with her hands in mid-air.
04:20		I would just do that and maybe just type with one hand or scroll down with the mouse and then change hand.	A2 puts both hands on the portable prototype in her lap. She reaches towards her keyboard with the right hand and imitates typing. She then puts her right hand on the mouse and imitates scrolling. She lets go of the mouse, takes her right hand back and reaches out with her left hand before taking it back and placing both hands on the portable prototype.
04:26		I did like the idea of, um ... almost warming up my hands with eh.	A2 briefly lifts up both her hands, rubs her fingers at the palms, and puts them back down, moving them on the surface of the portable prototype. She then lifts them both up again and rubs them together. She places them back down on the portable prototype and strokes it.
04:35		I tried as well to put it on my back.	A2 points and reaches towards her lower back with her right hand. She holds up the
04:38		But again, I was afraid to squish it.	A2 lifts up the portable prototype with her left hand and points towards the sensing circuit on one of its ends. She covers it with her hand.
04:42		So maybe I was thinking if rather than having the circuit like on the actual side, to have it on the extremity.	A2 holds up the portable prototype with both hands at its middle so one end is resting on her upper legs, the other pointing up. She then places it back down on her lap and points towards the circuit with her right hand, her left hand resting on the lower part of the prototype. She covers the circuit briefly with her right hand, lifts this end of the portable prototype slightly with the left hand and cups an area at the small side of it, next to the power connector.
04:54	I	Uh-uh.	
04:54	A2	Maybe, you know, then if you put it here at the back it was there then you wouldn't be afraid to squash it.	A2 puts the portable prototype across her lower back with the circuit and battery cable at the side of her body. She touches the small side of the prototype with her right hand. She rearranges the portable prototype carefully, placing it further behind her back while holding it up with her hands.
05:02		But I did try to put it on my back as well and it was nice.	A2 leans slightly back against the portable prototype, keeping her hands at its sides.
05:06		Especially sometimes if you have like back pain, it is actually nice to have something there.	A2 touches the side of her lower back briefly.

TC	ID	Conversation	Gestures
05:13		But I guess, you know, if you ... if you are maybe at home or somewhere else then it would be nice to just try like that.	A2 takes the portable prototype away from her back and holds it in front of her with both hands. Then she puts it across her right shoulder and rests her head against it.
05:25	I	Uh-uh	A2 takes the portable prototype away from her shoulder and holds it briefly between both hands before placing it across her lap.
05:27	A2	But yeah, I mean, in the office, though, I just had it here.	A2 places both her hands on the portable prototype and squeezes it.
05:30		So, the ... I think I prefer the blanket to the pillow.	A2 lifts her right hand, then places it back down on the portable prototype, and reaches for the wearable prototype with her left hand.
05:34		The thing about the pillow that I like it was the ... um ... the texture of the pillow. I even like the actual feeling of it.	A2 pats the portable prototype with both hands and starts squeezing it. She lifts one end up and squeezes it between both hands.
05:46		So, it was more as an anti-stress so, you know, you have got... I've got stuff and...	A2 lowers the portable prototype back onto her lap but continues squeezing it. She reaches across her desk and picks up and shows a stress-relief ball. She puts it back.
05:57		cause I kept doing that sometimes ... sort of grasping it, uh, and it was nice cause it was warm.	A2 turns slightly in her chair towards the interviewer, places both hands back on the portable prototype and squeezes it.
06:04		Although I felt... I think I kind of felt that I had something on me, cause I was holding it, so I felt like I had a cat or something [both laughing].	A2 turns towards her desk, her hands resting on the portable prototype. She briefly lifts up her hands, places them back down and starts squeezing the prototype.
06:14		Um, instead with the blanket it was more just wearing it and...	A2 turns towards the wearable prototype on the table to her left looking at it. She makes a sweeping movement with her right hand along her upper body and then rests it down on the portable prototype again.
06:23		I liked the idea that, you know, it was wearable, so it was more precisely like I felt because I could just move it around it.	A2 lifts up both hands, gestures, and then indicates a wrapping movement at shoulder level height.
06:34		I could wrap my hands, I mean, I could still put my hands on it, on top of it and I felt that, um, even dissipate the heat.	A2 makes a brief wrapping movement with both hands. She then briefly touches the wearable prototype to her left before she rests both hands down on the portable prototype in her lap.
06:42		It would transmit the heat to the body better because it was thin, so it would get the effect from both sides.	A2 lifts her right hand, palm up, and opens and closes her right hand. Then she circles her right hand in front of her upper body. She indicates the thickness with both hands, putting the index finger on top of the thumbs. She then places her hands on the portable prototype on her lap, slightly lifts it, and indicates with her right hand to the bottom side.
06:49	I	Uh-um	
06:50	A2	Um, instead with the pillow, it would just be like that. But I did like the texture of the pillow.	A2 puts both hands on the portable prototype in her lap and grabs it, slightly lifts it and squeezes it. She nods.
06:57	I	Okay. Thank you. So, um, and when you had both of the prototypes available, which one did you use?	A2 continues squeezing the portable prototype on her lap.

TC	ID	Conversation	Gestures
07:06	A2	So, I used, uh, the blanket. I think, yesterday all day, yes. I used it all day yesterday except from when I was charging.	A2 turns towards the wearable prototype on the table to her left and touches it briefly with her left hand. She reaches for the questionnaire on the table in front of her. She opens the folder and looks at the first page. She closes the folder. A2 indicates towards the wall mounted plug then turns and opens the questionnaire folder again.
07:18		Yes. So... there were a couple of times that I have to charge it. I think because I used it for quite a long time.	A2 turns the page and checks with her finger on the second page. She screens the questionnaire for a bit then closes the folder. She turns and indicates towards the plug again and then places both hands on the portable prototype on her lap.
07:30		And then today I started using the blanket and then I passed on to the pillow because I felt that my hands are, were getting colder. So, I think yesterday I was wearing leggings. So, it was a bit nicer to feel the heat on my legs.	
07:48		And now the legs, it was the hands as well, so I switched to the pillow to warm my hands a bit.	
07:56	I	Okay, thank you. Um, if you could've, would you have used both at the same time?	
08:03	A2	Yes. [laughing] Yes. [laughing] If I have to be honest, because I knew I was going to get both of them on the, on the last part of the experiment, so I was actually looking forward to that part because I thought, at first, I thought 'yes, I am going to have both so I can use both!', um, and then I realised 'oh no, I've just got one battery anyway, so I have to choose which one to use.	
08:26		Um, but no, I would've like to, to use both sometimes. So, I would probably put the blanket around me. Um, if I didn't worry about the battery the way they would have dropped. And this one on my lap so that I could just rest my hand and warm them up.	
08:46		Cause I think it does not matter how many layers you got, at least with me. Even if I put thick layers on. Because at work my hands always get cold and sometimes I'm trying to work with, um, gloves as well, like. Um, you know, fingerless glove. But it is not comfortable and then things, my hands might be warm, but my fingers are cold.	
09:16	I	Okay.	
09:17	A2	So, there is no balance with it. And I do like just you know, it is like a hot water bottle.	
09:25	I	Uh-um.	
09:26	A2	Sometimes, when I have a hot water bottle at home, I don't necessarily put it on my	

TC	ID	Conversation	Gestures
		back or any. I just hold onto it, almost hug it.	
09:38	I	Uh-um.	
09:39	A2	That's what I do to warm up my hands. So, yeah, no it would be nice to use both.	
09:45	I	Okay. Um, and did you think about taking the prototypes with you?	
09:52	A2	I did! [laughing] Um, you mean home or when I was walking around here?	
10:00	I	Yeah, both.	
10:01	A2	Both. Um, home yes. Like when I was leaving I was like 'oh, I wish I had this one' because I'm always cold when I'm there even when, because I am not there all day and I don't need the heater when I'm not there. I don't like, well, I don't like them going off while I'm not there. I just think it's a waste, cause I never know the time I get back home, so. Even if I can put the timer because I'm never sure what time I go back. I don't like waste energy. Um, So, usually, and I leave the window open so each time I get back it's always cold and I thought 'oh, if I could take one of these home, it would be nice'.	
10:39		Um, in here, sometimes I would have liked to. But then because of the battery, I didn't. I didn't because it wasn't practical. Um, because most of the time like - I didn't really because the battery is quite heavy so even if I put it into the, the pocket of one of the cardigans, it just is really heavy.	
11:05		Uhm, but probably, if there wasn't ... the battery side, I would just take it with me.	
11:17	I	Uh-um. Okay.	
11:19	A2	So, it has the potential of, yeah, of that.	
11:23	I	Okay. And um, you have already mentioned, and um, you also mentioned that in the questionnaire that the cable wasn't long enough -	
11:35	A2	Yeah.	
11:35	I	when you wanted to put the wearable prototype around your shoulders. So, um, what length do you think ...	
11:48	A2	You know, that's the thing. Probably even this length is, is about right. Maybe it's because ... the battery seems so bulky and heavy that I was afraid that if I would move it would drop and pull something.	
12:08	I	Uh-um.	
12:08	A2	Um, cause maybe that's the thing. Even when I was showing you how I was using it, I realised that the cable actually is not, is not short.	
12:17	I	Uh-uh.	

TC	ID	Conversation	Gestures
12:18	A2	Uh, it is quite long. But because of the battery I felt I couldn't move. So maybe. I don't know maybe if it was, I don't know how long is this. Maybe it's what? Just less than a metre?	
12:30	I	Uh	
12:30	A2	Probably. Or just about a metre? Maybe if it was two metre, you are, you would feel that you could leave the battery on the floor and still have, so at least it wouldn't drop anywhere and have uh... Cause that's the thing usually if you start lifting and putting them down then the battery lifts. Maybe about two metres. You wouldn't have to worry about the battery itself even if it is bulky.	
12:57	I	Uh-uh. Was it also an issue with the, with the portable, like the cushion?	
13:07	A2	Uh	
13:07	I	The length of the cable. Did you feel it was an issue with that one?	
13:12	A2	Oh, you mean with the inside, the warm	
13:17	I	No, no, I mean, yeah, did you think the cable was not long enough, when you were using it?	
13:23	A2	Oh, yeah, you mean this one but then that. No, with this one it was fine. Probably because, because it is not wearable. Because it is portable, as you say, then I did not move it as much, as I was trying to do with the blanket.	
13:40	I	Uh-uh.	
13:40	A2	Um, so, this one was fine because I just basically left it on my lap or when I did try to put it on my back I was just trying to rest the, the battery on the back of the chair as well.	
14:02	I	Uh-uh.	
14:04	A2	Um, I think it was easier compared with this one cause it was closer to this back seam and to the desk compared to using that.	
14:15	I	Okay, cool. Yeah, thank you.	
14:17	A2	Yeah?	
14:18	I	Those were all the questions I had. Thank you very much!	
14:21	A2	No worries.	

Participant A3

TC	ID	Conversation	Gestures
00:04	I	I have a few questions, um, because you have been, I have given you these prototypes to	

TC	ID	Conversation	Gestures
		test. So, thank you very much for that already.	
00:13	A3	Welcome.	
00:14	I	And, um, I would like to know how you used the prototypes. If you could show me, eh, for the cushion one first because I think that's the one I gave you first.	A3 reaches for the portable prototype
00:25	A3	This one? Um, I just put it at the back of my chair.	A3 moves the portable prototype between both hands;
00:28			A3 leans forward and places the portable prototype across her lower back
00:28	I	Yeah.	
00:29	A3	So, yeah, just like that.	A3 puts her hands in her lap and leans back on the portable prototype;
00:31	I	Okay.	
00:32	A3	And, uh, for this one, I, like, I use it differently.	A3 removes the portable prototype from her lower back, putting it to the side; A3 reaches for the wearable prototype opening it up;
00:40		So sometimes, I was like carry it on like as a cushion, like this.	A3 moves the wearable prototype behind her back first and then moves it at two corners up from the waist over the shoulders so that the wearable prototype covers the back area and her hands holding it at the corners meet at her chest.
00:45		And ah, today I put it at the back of my chair and, eh, like because the chair is like, ah, I can, ah, lean on it. So, yeah, that also give me some warm. Yeah.	A3 moves the wearable prototype away from her back and arranges it over the backrest of the sofa; A3 leans against it
00:58	I	Okay, yeah, sounds good. So, ah, which one did you use when you had both available?	
01:06	A3	Uh, this one.	A3 reaches back and pats the wearable prototype, which is still spread over the backrest.
01:07	I	This one.	
01:07	A3	For sure.	
01:08	I	Only this one?	
01:09	A3	Yeah.	
01:10	I	Okay. Okay, cool. Um... I mean you, um... because I only gave you one battery for both.	A3 picks up the portable prototype and holds it in front of her
01:18	A3	Yeah.	
01:19	I	If you had, if it had been possible for you to both, to use both at the same time, would you have done so, or?	A3 plays with the portable prototype, which sits on her hands and rolls it back and forth slightly with her fingers;
01:26	A3	Um... I think I would just stay with this one	A3 stops playing with the portable prototype, moves it over onto one hand and lifts it up slightly; A3 slightly turns her upper body towards the backrest and pats the wearable prototype
01:30		cause this one, like, it gives, like, it, like, um,	A3 grabs and picks up a part of the wearable prototype, looks at it and holds it between her fingers
01:34		when, whenever I feel cold, I feel cold at my back	A3 lets go of wearable prototype; A3 leans forward and touches her upper back with her left hand

TC	ID	Conversation	Gestures
01:40		so, this helped. Just, it's enough for me. And it's also... um... it don't interfere my sitting.	A3 pats the wearable prototype and points towards it
01:47		This one is a bit, like, I feel, sometimes I don't feel very comfortable with this.	A3 picks up the portable prototype, holds, moves, turns, and squeezes it in front of her with both hands
01:53		And this one is quite useful. Yeah.	A3 puts the portable prototype down next to her and turns towards wearable prototype patting it
01:55	I	Ah, okay, okay. Because, um, yeah, in your, in the questionnaire you filled in, you mentioned that you did not feel quite comfortable using the	
02:06	A3	Yeah.	
02:06	I	cushion one and that it was big and, um, so do you have any suggestions of how that could be altered? Or do you...	
02:19	A3	Um... I think it depends. Like for the chair, for example, uh,	
02:25		if I am using this with the chair at my home, it would be useful because the chair is not quite, ah, how do you say... ah... designed for office.	A3 picks up the portable prototype with the right hand, places it across her right upper leg, and pats it
02:39		Um... but the chair I am sitting at my office is quite like ah.... Ah... good so I don't need	A3 holds the portable prototype in place with one hand
02:48		any cushion to, to, to help me to sit better. Um, so, I mean,	A3 pats the portable prototype with the right hand and then holds it with both hands on her right upper leg
02:55		like if, like, this one, ah, in my ... if I am using it with, with the chair I am using at home, it would be better	A3 lifts the portable prototype up with both hands, moves it between her hands, turning it around and shifting it from left to right hand
03:06		than this one.	A3 moves the portable prototype away from her body with right hand, turns her upper body slightly and indicates towards the wearable prototype with her left hand
03:07		Yeah, so it depends, I think.	A3 puts down portable prototype
03:09	I	Ah, okay.	
03:10	A3	Yeah.	
03:10	I	Okay, thank you.	
03:10	A3	Yeah.	
03:11	I	Um, yeah okay, no, so I understand. The other question I had, uh referred to... because you also mentioned that you could not cover your back with this, but you already explained with the use of	
03:25	A3	Yeah. Yeah.	
03:26	I	the other one how that... Um, was meant. So, um, the last question [laughing]. Okay, because you also, you mentioned, um, as well during, um, in the comfort questionnaire that you easily feel cold and, um, that you usually dress more, you put on more clothes than other people	
03:44	A3	Yeah.	
	I	when it is cold in the office.	

TC	ID	Conversation	Gestures
03:46	A3	Yeah.	
03:47	I	And do you think that, um, that, um, these devices would have helped you?	
03:53	A3	Yeah.	
03:54	I	And would you use them?	
03:58	A3	Yeah, I mean, it would be really helpful cause today, ah, especially I feel	
04:05		this is quite useful cause I'm travelling with bicycle.	A3 points with her finger to the wearable prototype over the backrest;
04:10		So, I kind of, um, feel I've, ah, got some sweat. Like, yeah, so my, yeah, I think,	A3 gesticulates and takes the fabric of her sweater into her fingers just above the waist;
04:15		my, my t-shirt was like, ah, kind of, ah, wet in some way. Um... so when I came in I was like hot and um... I took off my jacket and then I feel cold.	A3 moves her right upper arm up and turns her gaze and points towards it; A3 takes the fabric of her sweater at the right upper arm briefly between the fingers of her left hand
04:31		Like, yeah, so, so I used this, um, just to act as a jacket. Um, I, because like, I mean, I can adjust the temperature so, um... like, when I don't feel that cold I can turn it down. Because, um, before it without this I wore my jacket on and eh, like sitting in, indoor and eh, if I, if I wear a jacket on, if I am going out then I will be cold outside. So that's why I think this is quite useful.	A3 points with her finger to the wearable prototype over the backrest;
05:08		Like just for me to, um, adapt special time to warm up and then, um... it's fine. And then I can, like, whenever I went out I can take my jacket. So, it want, like, like, it will help me to balance the temperature.	
05:26	I	Okay.	
05:27	A3	Otherwise, like I feel, I feel cold outside.	
05:29	I	Okay.	
05:30	A3	Yeah.	
05:31	I	And, um, well, actually I just came up with another question	
05:34	A3	Yeah.	
05:35	I	if I may ask that as well. Um, I mean, both devices are portable, so you could take them with you.	
05:43	A3	Yeah.	
05:44	I	Would you do so?	
05:45	A3	If it looks better, I will [laughing].	
05:48	I	Okay.	
05:48	A3	I mean, this black thing. Ah, I mean, if it's, it's just like a normal, um, cushion or a normal, ah... how do you say that, um, blanket.	A3 turns around towards the backrest, touches the wearable prototype and turns back again;
06:02		I think I might use it because, um, for this one... um... I actually wear it in my office, like, while I walk around in my office. So... it's, like, I mean, I will use them, like I will carry them around.	A3 points with her finger to the wearable prototype behind her back;

TC	ID	Conversation	Gestures
06:18		But this one, I think it will be more difficult, yeah,	A3 puts her hand on top of the portable prototype next to her on the sofa;
06:23		this one is like I just have it on, then it's done, yeah.	A3 points towards the wearable prototype behind her back; A3 makes a throwing movement over her shoulders;
06:27	I	Okay, brilliant. Thank you so much.	
06:29	A3	You are welcome.	

Participant A4

TC	ID	Conversation	Gestures
00:05	I	Okay, so, thank you very much for participating and testing my prototypes. So, I have some questions on how you used them and ... um... maybe... um... if we could start with this one	
00:27	A4	The cloak.	
00:29	I	Yeah, so how did you, when I gave you this prototype, how did you use it when you had it?	Interviewer puts the wearable prototype on the desk in front of A4; A4 rearranges the folds and places the control and battery next to it on the desk;
00:38	A4	I folded it, like this.	A4 lifts up the wearable prototype and first lays it in its full size on the table. Then she folds it in half holding it by its edges.
00:44		And then I put it on my ah, on my lap. Here.	A4 places the folded prototype over her upper legs
00:49		And then I discovered that only the, only this part can feel the, can feel warm but my feet are still ah feel cold.	A4 places her hands in her lap first and then indicates the span of her upper legs with her hands.
00:59		So, I just like this, put it to cover my feet.	A4 folds open the prototype so it covers her lower legs.
01:05	I	Okay.	
01:06	A4	Yeah. But, um, here I think because there is no carpet so there is dust on the floor. But I think in my office and at home with the carpet, so it should be fine.	A4 grabs the lower part of the prototype and gathers it up, folding it back into half. She lifts it off her lap and places it on the table in front of her.
01:19	I	Okay.	
01:21	A4	But I'd like to wearing it like a real cloak put it on my shoulders but because it is too obvious for other people to saw it, so I just give up the idea.	A4 makes a sweeping movement with both of her hands over her shoulders.
01:34	I	Okay, so... Um, thank you. And then, um, I gave you the other one. So...	Interviewer exchanges takes away the wearable prototype and hands A4 the portable prototype.
01:44	A4	Yeah, there are a lot of ways to use that.	A4 places the portable prototype in front of her on the table and rests her hands on it.
01:49		At first, I just hold it like, like this...	A4 grabs the portable prototype and pulls it towards her body embracing it with her arms.

TC	ID	Conversation	Gestures
01:52		and then when I'm typing and writing I put it on my lap.	A4 makes a typing movement with her fingers, lets go of the prototype so it comes to rest on her lap.
01:57		And sometimes I put it like this on the back of my waist. Because if I could feel warm on my waist, the whole body will feel much better.	A4 grabs the prototype with her left hand and puts it behind her back holding it there with both hands. Then A4 puts the portable prototype back on the table in front of her.
02:10	I	Okay, sounds good. And um -	
02:14	A4	Yeah. And I also like to crush it like this [both laughing]	A4 grabs the portable prototype and starts squashing it.
02:21	I	And when you had both of them available, which one did you use?	Interviewer hands back the wearable prototype to A4.
02:26	A4	Um... I preferred to use this one but actually I used this one.	A4 holds the wearable prototype in her left hand. She pats the portable prototype with her right hand first and then points towards the wearable prototype in her left hand.
02:32		Because... uh... yesterday when I'm feeling cold I like to have some warm. But because I need to write and typing and reading the books and papers, so I can't spare my hands to hold it or crush it so that's why I use this one to cover my ah my leg and feet.	A4 gestures with her right hand. She puts down the wearable prototype on the table and briefly reaches towards the portable prototype. She makes a squashing movement with her hands in the air and then places her hand on the wearable prototype. She indicates towards her legs with her hands.
02:52	I	Okay, brilliant and um -	
02:55	A4	But you said, you told me before I start to use it I need to turn on this ah turn on this device, but I forgot. Only after one or two hours I remember that I need to turn on this device. So, I think, maybe so around 9 or 10 o'clock there is no data set from this device.	A4 searches for sensing circuit in the folds of the wearable prototype and points towards it once she finds it
03:25	I	Okay. No, that's fine. I mean, so I know that you used it longer now. That's fine, don't worry, I mean.	
03:34	A4	Um... when I, when I leave my office it is around half past ten or ten o'clock.	
03:42		I just put it aside and go out. So, when I come back I didn't realise that I did not turn off it before I leave my office. In fact, I saw the red light flashing I forgot which of the board. I started turn it off.	A4 briefly grabs hold of wearable prototype and slightly lifts it off. A4 searches and points towards the circuit light.
04:04	I	Okay, yeah. Was the, was the heat still on or was it just the sensing circuit?	Interviewer points towards the sensing circuit
04:13	A4	Just the sensing circuit.	A4 taps the LilyPad XBee board on the wearable prototype with her finger.
04:16	I	Okay, so don't worry. That's fine. Don't worry. So, the next question would be like because you could only use one of them at a time. Would you have liked to use both at the same time?	
04:31	A4	When I'm relaxing yeah, I prefer to use both of them. But not working. [both laughing]	
04:38	I	Yeah, I totally understand. Um, and you also just mentioned it now, but you also mentioned in the questionnaire that you	

TC	ID	Conversation	Gestures
		would have liked to take the devices with you but because of the battery but also because you thought, um, people would ask you questions.	
04:58	A4	Yeah.	
04:59	I	Can you explain in a little more detail what you mean?	
05:07	A4	Oh, so... I didn't do that but I'm only worried that if I'm wearing a black cloak then I got out of my office and I get a cup of water or coffee and then the other people, my friends saw me, I'm just afraid they come here and ask me what you are doing and what is this and how did you made it and then I had to explain oh it is not my work it is my friend's prototype so the functions the purpose of the experiment so I just don't want to answer those bunch of questions.	A4 points towards the wearable prototype on the table in front of her.
05:44	I	Okay, so... Okay, but otherwise you would have taken it with you if you...?	
05:53	A4	Yeah, yeah. If it's weekend, um, only a few people was around the office, maybe I would wearing it with me ... anywhere.	
06:04	I	Okay. Okay, thank you. Um, and, um, about the other prototype, the cushion one, you mentioned that it lacked a bit of flexibility in comparison to ... to the wearable one.	Interviewer points towards the portable prototype. A4 nods.
06:23	A4	Yeah. So, like I said, um, this one I can I can fold it or stretch it or change the, the forms	A4 picks up the wearable prototype and unfolds the upper part spreading it out slightly. She lets go of the prototype and indicates different sizes with her hands.
06:33		or even I can make it much thinner by make it double layers.	A4 picks up the edges of the wearable prototype and folds them together
06:39		But this one I can only take it as what it is.	A4 grabs hold of the portable prototype, lifts it up and turns it in her hands.
06:45	I	Yeah... okay. Do you have any suggestions of how you would have changed it to make it more flexible or...?	A4 puts the portable prototype back on the table.
06:56	A4	Um, I think this one could make it more like an animal like a little cat.	A4 starts stroking and rolling the portable prototype on the table.
07:06		When I was four or six years old I usually like to holding, holding my little dogs on my, on my lap top? - yeah on my lap top so when I knew this prototypes it reminded me that a little dog.	A4 takes up the portable prototype and puts it on her lap.
07:30		So maybe it will have some design, some embedded design, which can detect my body temperature and the environment temperature, so it will detect my hands,	A4 gestures towards the portable prototype in her lap making suggesting inserting something into it. Then she puts both hands on the prototype.
07:50		if I put my hand like this one so it started to generate the heat automatically	A4 picks up the prototype and puts it back on the table. She puts both hands, next to each other, on the portable prototype. Then turns them palms up and makes a convective movement.

TC	ID	Conversation	Gestures
07:58		and if my hands left of it, it just become cooler but still have some energies.	A4 takes her hands off the prototype and makes a lowering movement with her right hand, palm facing down, before moving both her hands upwards, palms facing up.
08:04	I	Okay. So, yes	
08:07	A4	Like in an interactive way.	A4 makes a cycling movement with her hands.
08:11	I	Yes, I think you mentioned that in the questionnaire	
08:13	A4	Yeah.	A4 nods.
08:13	I	as well. So that was one of my questions as well. [A4 laughing] So you answered it already. And um, the one other thing I wanted to ask you is because in on this the wearable prototype um you mentioned that it would be nice if it changed colour according on your body temperature. So, um did you have anything particular in mind like of how that would happen when you wrote that?	
08:41	A4	Um... so I am only thinking when people feel cold, maybe, I don't know other people but I only say it based on my own experience, when I feel cold I like to see some red colours or orange colours because it is close to the sun and give me the hint that some warming temperatures or the warm light come towards me.	A4 indicating towards herself. She props up her elbow on the table and keeps moving her right hand to and fro.
09:11		When I feel very hot, I like to receive cold colours, like the blue, the green, because it will give me the impression the temperature of the ocean in summer or the, or the fresh air come from the woods or the grass field.	A4 continues gesturing with her hands, both elbows propped, up to support her words, shaping a ball with her hands first, then listing up by wrapping an individual finger around another one on her other hand, and finally moving her hands to and fro in direction towards herself.
09:40	I	Okay	
09:41	A4	So maybe if the prototype can detect my body temperature, if my body temperature is about the normal level so it will stop generating the heat	A4 picks up the hems of the wearable prototype, lifts it up a bit and puts it back down. She indicates a line in mid-air with her right hand, her left hand still touching the wearable prototype.
09:58		and the colour will change from the warm colour to the cold colour.	A4 makes a swiping movement from left to right with her right hand in mid-air.
10:02	I	Okay.	
10:02	A4	Yeah.	
10:03	I	Okay, now I understand. [A4 laughing] Okay, Thank you so much. Yeah, I don't have any other questions. Well, thank you again -	
10:12	A4	No problem.	
10:12	I	for participating.	

Participant A5

TC	ID	Conversation	Gestures
00:04	I	First of all, thank you very much for testing -	A5 has both prototypes sitting on his upper legs, the wearable prototype on his right leg, the portable one on his left leg.
00:06	A5	A pleasure.	
00:06	I	my prototypes and, um, I have some questions about yeah, how you used them and how you liked them.	
00:13	A5	Okay.	
00:14	I	And, um, if we could start with, um, the one you had first, I think, was the portable, yeah, so, um, how did you use this prototype?	A5 is holding up the portable prototype with his left hand.
00:28	A5	Um, I basically used it as I had it, basically like a hot pad on my desk.	A5 holds up the portable prototype with his right hand but to the left side of his body in mid-air, at about desk top height.
00:35	I	Okay.	
00:36	A5	And I just put my hands on it because it is my hands that feel cold more than anything else.	A5 raises his left hand and puts it on top of the portable prototype. He lifts his hand back off the prototype and turns it with the palm facing upwards while he lets the prototype sink down on his left leg.
00:40		Um, so I just the way on it basically if I was working away	A5 turns his left hand, palm facing downwards, and puts it back again on the portable prototype, which is lying across his left upper leg.
00:45		or sometimes I put my forearms that were on it as I was typing or something like that.	A5 moves his arm forward so his left forearm comes to rest on the portable prototype half-way. He stretches both arms out, the left forearm still on the portable prototype and makes a typing movement with his fingers.
00:49		That's how I used it. Um, yeah.	A5 shifts the portable prototype so it comes to lie along his upper left leg.
00:54	I	Okay. Yeah, sounds good. And, um, then I gave you the other one. And if you could briefly show me and explain to me how you used that one.	
01:04	A5	Very similar, except I could shove my hand right in the middle of it. Basically, so it was completely surrounded by heat rather than just laying on top.	A5 takes up the wearable prototype with both hands first, then puts his right hand inside the folds of it while still holding it with his left hand. He holds it like that for a few seconds and then takes his right hand out of the folds and puts the wearable prototype back on his lap. He puts his left hand briefly on top of the portable prototype.
01:14		Um, it was also easier to walk around cause I, because it was just smaller generally, or flatter.	A5 takes up the wearable prototype with his right hand and then passes it to his left holding it with both hands in front of him.
01:21		But, um, when you have limited space still took up some space but with limited space it was a bit easier.	A5 puts the wearable prototype back down on his right leg and takes up his hands holding them fingers spread, palm down, in front of him. Then he reaches for the wearable prototype with both hands briefly

TC	ID	Conversation	Gestures
			holding it between them for a moment before taking up both hands again in the same posture mid-air.
01:28		It was at the right height for typing and things like that.	A5 puts down his right forearm on the wearable prototype and the left forearm on the portable prototype on his lap and types with his fingers.
01:34		Um, so that's how I used this one compared to that one. But they are both to quite similar.	A5 grabs wearable prototype briefly with his right hand before tapping the portable prototype with his left hand.
01:37	I	Okay, yeah. And when you had both of them available to you, which one did you use?	
01:44	A5	This one.	A5 holds up the wearable prototype with his right hand.
01:45	I	This one. All the time?	A5 puts down the wearable prototype on his right leg.
01:46	A5	Yeah.	
01:47	I	Okay. Um... would you have used both of them at the same time if you could have? Because you could only use one.	
02:00	A5	Um, probably not. If I had two of these I might have used two of these at the same time.	A5 holds up the wearable prototype with his right hand.
02:08		But then it is all taking up a lot more room.	A5 puts the wearable prototype back down on his right leg.
02:14		Ah, I was just, I was just switching hands. In fairness, to which one was feeling colder. When I was typing or writing or something like that. Um, so that's I just used the one.	A5 is putting down his hands on the wearable prototype, alternating between his right hand and left hand for a few seconds. Then he makes a typing gesture with his fingers and rests his hands briefly in his lap before indicating towards the wearable prototype.
02:23		And I preferred this one, as it is both hands.	A5 picks up the wearable prototype and briefly holds it up before placing it back down on his right leg.
02:25		You can easy put both hands in this if you want. o.	A5 briefly puts both of his hands on the wearable prototype.
02:28		Same with this in all fairness. So, you know what, I probably would not have used two.	A5 briefly puts both of his hands on the portable prototype.
02:32	I	Okay, cool. Um, did you think about taking any of the prototypes with you at some point or would you have liked to?	
02:43	A5	Um... you mean back to my flat or something like that or...?	
02:50	I	Or other places at university.	
02:52	A5	Or other places. Um... I have taken portable heating devices other places, but I would suggest these are so much bigger than those.	A5 cups both hands briefly, palms facing up. He relaxes both hands and puts the right hand on the wearable prototype.
03:02		Um... I often have the, um, I don't know if you know these things that you snap a penny and that's that. I have used that loads.	A5 lifts up both hands imitating the snapping movement between his hands
03:09		Um, so I certainly am quite happy to take the portable heating devices elsewhere. I	A5 briefly indicates towards the wearable prototype with his right hand.

TC	ID	Conversation	Gestures
		think, I am finding these just a bit too bulky to be elsewhere	
03:19		and if I am back at my sort of home environment or things like then I ah, I probably wouldn't use something like that, I would just put some more clothes on or turn the heating on, in all fairness. Um, open the window maybe getting some cooling.	
03:34	I	Yeah. Okay.	
03:36	A5	But I got much more control than I do in an office space.	A5 gesticulates with his hands.
03:41	I	Yeah, I mean you mentioned in the questionnaire, um, that you would like to have them a little bit smaller?	
03:54	A5	Yeah.	
03:54	I	And, um, once you mentioned like mouse pad size or something...	
03:58	A5	Yeah, something like that. That just... As I was working away, I was feeling a mouse mat is a quite common thing. So, you could even combine the two that would be brilliant. [A5 laughing]	A5 stretches his right arm out in front of him and makes a brief typing imitation with his hands
04:09		But, yeah, I just like to put my hand somewhere for it to warm up because it is always my hands that feel cold rather than the rest of me.	A5 moves his right hand in front of him and stretches his arm back out. Before resting his hands in his lap, he holds up both hands, fingers spread out, in front of his body.
04:17		But in all fairness, if you had a heated foot warmer or something like that for my feet, I would probably use that as well. [A5 laughing]	A5 lifts both hands up, sweeping them slightly outwards in front of his body, arms stretched out. He repeats the gesture once.
04:23		Um... but yeah, uh, that kind of size for working in an office I would suggest even smaller, if I was taking it out, if it was me.	A5 forms a mouse mat size with his hands in front of him.
04:34		More ball (?) format sized	A5 indicates the size between his right index finger and right thumb.
04:35	I	Okay. And, um, in the comfort questionnaire you mentioned that you would wish for a personal radiator in the office.	
04:45	A5	Yeah, really.	
04:47	I	How, would, like, how would that compare then with these two devices? Would you prefer a radiator compared to like a more portable wearable thing like this?	
05:00	A5	Um... the way I was probably using the devices I would say that it was very similar how I would use a radiator rise,	
05:07		I would have a radiator or something right beside me and I would basically lean against it because I just do that everywhere I go, I lean against radiators.	A5 stretches out his right arm to his right. Then he slightly moves to the right with his upper body to imitate leaning, and then moves back.
05:18		Um, so, um, I probably said that because that is what I am familiar with more than anything else. If I, um, had something like the mouse mat or something like that,	A5 puts his hands back in his lap. He takes them up again to form a mouse mat sized object in mid-air.

TC	ID	Conversation	Gestures
		maybe I wouldn't need, um, would even have thought of having a personal radiator as well.	
05:32		Um, and I suppose at least to have something like a mouse mat is more personal. If I switch the radiator on let's say there are six of us sitting quite close together they are always going to all feel the effect. Um, so I would be less popular in the office if I did this.	A5 gestures briefly with his right hand.
05:09		So, I thought of the radiator in an ideal world. But, um, as a compromise, something like this is probably better.	A5 briefly indicates with his right hand towards the wearable prototype.
05:57	I	Okay, cool. Thank you. Those were all the questions I had.	
06:03	A5	Okay.	
06:03	I	Thank you very much again.	
06:04	A5	No problem.	

Participant A6

TC	ID	Conversation	Gestures
00:03	I	First of all, thank you again for testing my prototypes.	
00:07	A6	No problem.	
00:07	I	So, um, I have some questions on how you used them. So, if we could maybe start with this one.	
00:15	A6	Yeah.	Interviewer hands the wearable prototype to A6.
00:16	I	And, um, if you could tell me and show me how you used this one.	A6 puts wearable prototype down on her crossed legs but keeps its folds in her hands.
00:20	A6	Um, me, I kind of used it across my legs like this.	A6 unfolds the wearable prototype so that it spans in its full width between her hands but is still folded in half in the other dimension. She lifts it up and then places it on her lap, so it covers her upper legs.
00:26		Or maybe I sort of folded it out to the full, squaring it, folded it back open like this.	A6 picks up one end of the wearable prototype folding it open across its full length and holding it up with both hands in front of her upper body. She puts the wearable prototype over her lap so that it slightly reaches over her knees, covers all of her upper leg, and falls down their sides. She folds back the remaining cloth at the top over the upper part of her legs. She adjusts the folds over her legs, so it lies smoothly.
00:34		Um, mostly because when I am at home I have a blanket like this.	A6 rearranges the folds of the wearable prototype and crosses her legs underneath.

TC	ID	Conversation	Gestures
00:39		So, it's always my legs that get cold for some reason or feel cold. So, it was, uh, nice that	A6 indicates towards and touches her legs with her right hand. She briefly picks up a fold of the wearable prototype and releases it again.
00:44		I could just sort of adjust the length that I wanted it across, you know.	A6 picks up the wearable prototype at its upper hem and lifts it up in front of her. She puts it back over her legs in its full length.
00:49		So that's how I mostly used that one.	A6 lifts her right hand and lets it fall on the wearable prototype on her right knee.
00:52		Um, maybe I would pull it a little bit up around here.	A6 picks up the hem and pulls the wearable prototype up to her shoulders so it covers her upper body.
00:56		But it was mostly on this sort of area that I used this one.	A6 makes a circling movement with her right hand above her legs.
01:00	I	Okay, brilliant. Thank you so much.	A6 picks up the upper hem of the wearable prototype and folds it back down on her lap.
01:03	A6	No problem.	
01:04	I	And, um, I think, then I gave you this one.	A6 folds the wearable prototype together and puts it next to her on the sofa. The interviewer hands her the portable prototype.
01:05	A6	Yeah. With this one when I used it, it was again on my lap	A6 receives the portable prototype and holds it briefly between her hands and puts it on her lap, her hands resting on it.
01:11		and I kind of, another thing that gets cold is my hands, so I would rest my arms on it like this. And it was kind of a good height to sort of rest my arms and type on my laptop.	A6 lifts her hands slightly, turning them palm up. She puts her hands and arms back down so that her lower arm and wrist come to lie on the portable prototype whereas her hands are free in mid-air. She imitates a typing movement with her hands.
01:23		Um, so it fit perfectly in that sort of gap that's there.	A6 lifts her hands and arms slightly. She touches the portable prototype with her hands briefly and then makes an encompassing movement around the portable prototype indicating the space and dimensions. She makes another typing movement with her hands, the arms suspended in mid-air.
01:28		Um, but that's the only way I used this one. It was mostly on the lap area I used both. Um, yeah.	A6 touches the portable prototype briefly and then sweeps with her hands over the lap area. She briefly touches the wearable prototype lying next to her on the sofa.
01:39	I	And, um, when you had both of them available to you for another two days, but you could only use one at a time, which one did you use?	A6 picks up the wearable prototype and holds it between her hands, the portable prototype still resting on her lap.
01:48	A6	Um, this one. I preferred this one over that one.	A6 slightly lifts the wearable prototype higher. She picks up the portable prototype with the right hand and moves it from her lap onto the sofa and then pats it briefly.
01:53		Just because to me it felt more sort of versatile in the fact that you can, um, adjust the area that you are covering with it.	A6 gathers up the hem of the wearable prototype then holds it up in front of her, with its full length hanging down. She then sweeps it towards her body so that it is first covering her upper body but then comes to rest on her lap covering her upper legs.

TC	ID	Conversation	Gestures
02:02		Um, but also place it in different areas. It is a lot sort of more versatile for me than the pillow-type prototype, so I preferred to use this one.	A6 lets go of the wearable prototype, picks it up again and holds parts of it in mid-air and then lets it fall back on her lap. She rearranges the wearable prototype a bit then turns towards the portable prototype on her left and pats it with both hands. She turns back and touches the wearable prototype on her lap with both hands.
02:15	I	Okay. Yeah, and, um, because you could only use one at a time, would you have liked to use both if you could have, or?	A6 picks up the upper hem of the wearable prototype again and rearranges it on her lap.
02:24	A6	Um, I don't think so. I liked this one the best than this one.	A6 shakes her head and picks up the upper hem of the wearable prototype with both hands, lifting it up in front of her. She lets go of the wearable prototype with her left hand and pats the portable prototype on the sofa next to her.
02:30		Just because at home I use blankets. I just like blanket-type things because they are just so, um, sort of multifunctional.	A6 gestures with her hands, briefly picks up the upper hem of the wearable prototype on her lap and puts it back down. She continues gesturing with her hands in mid-air.
02:39		You can use them in different places and it is really easy to just sort of, if you got a cold neck you could chuck it around here.	A6 picks up the wearable prototype, folds it together across its width and puts its upper part over her shoulder next to her neck and pulling the middle bit of the wearable prototype under her chin, like a scarf.
02:45		But with this it's like there's not so many places you can have it. Like, cause it doesn't, like,	A6 puts the wearable prototype back on her lap and slightly turns towards the wearable prototype, picking it up with her left hand and holding it briefly between her hands in front of her. She puts it on her lap and puts her wrists onto it.
02:53		rest on, like, I couldn't really put it round my neck like that. Well, maybe I could.	A6 puts her right hand on her left shoulder then picks up the portable prototype and puts it on her left shoulder. She leans her head against it and lets go of it with her right hand, so the portable prototype is stuck between her head and shoulder.
02:59		But it feels a bit more like bulky than this. Um, yeah, I prefer this one.	A6 takes the portable prototype off her shoulder, holds it briefly in her hands and then puts it down on the sofa next to her. She lifts up the wearable prototype from her lap, unfolds it and arranges it over her lap.
03:08	I	Okay. Um, did you think, um, about taking the prototypes with you at any point? Because you used them in your office.	
03:19	A6	Yeah.	
03:20	I	But when you left the office.	
03:22	A6	Um, like when I went outside, would I wanna take them with me?	
03:26	I	Yeah, or somewhere else, meeting your supervisor.	
03:29	A6	Um... actually, there was one time when I went to work in the library. It would have been quite useful there because I was in the	A6 gesturing with her hands making an opening, sweeping movement with her right hand.

TC	ID	Conversation	Gestures
		postgrad reading room and this guy had the window full open and it was so cold.	
03:43		And I wondered why no one was sitting down that end of the room and there was just one guy with the window wide open and there was a breeze coming in. And I was like: 'uh, now I know why no one sat down here'.	A6 holds up both hands' palms facing forward in front of her. She places them on her lap but takes the right hand up again palm facing forward first and then sweeping it to the left letting it fall into her lap. She takes her right hand back up and makes a sweeping movement to the right.
03:53		But it would have been useful to have something like this then.	A6 puts her right hand on the wearable prototype on her lap.
03:55	I	Okay.	
03:56	A6	Cause I was working there with my coat on and it felt a bit like... I don't really like working with lots of layers of clothing on.	A6 presses her upper arms against her sides, puts up her shoulders, and takes up her hands bringing her lower arms close to her upper body and typing with her fingers. She loosens the tension in her upper body again and makes a movement like adding something on.
04:03	I	Okay, good. And, um, in the questionnaire you mentioned that the battery restricted where you placed the sheet -	A6 nods.
04:14	A6	Yeah.	
04:14	I	So where would you have like to place it?	A6 plays with the hem of the wearable prototype on her lap.
04:19	A6	Um, I think, maybe I would have liked to get up and walk about with it on?	A6 picks up a fold of the wearable prototype on her upper leg and lets go of it again. She lifts up her hands and gestures.
04:29		And just sort of if I had it around my neck it would have been better if the battery was sort of attached to it.	A6 gathers up the wearable prototype and holds it up briefly before placing it back down on her lap. She is indicating with her left hand towards the end of the prototype.
04:35		Um, because I felt like I had to place it on my lap, which it was good for because I could put the sort of battery on the side.	A6 unfolds the wearable prototype on her lap moving it over her knees with both hands. She lifts up her left hand mid-air, her right hand follows and both hands indicate towards a position next to her to her left.
04:43		But then I'd have to move the battery with having to move this	A6 grabs the air with her left hand while her right hand grabs the wearable prototype. She moves both hands over to the right, moving the wearable prototype of her lap.
04:48		and I just felt if it was attached to this it would make it a lot more, um, like, versatile to move around a lot easier.	A6 rearranges the folds of the wearable prototype so it covers her legs again. She pats the wearable prototype and picks up its hem holding it up in front of her. She moves the wearable prototype at its hem left to right and slightly forward and backward.
04:58		Um, I just felt that the battery restricted it sometimes.	A6 puts down the wearable prototype and arranges it over her upper legs.
05:02	I	Okay, okay. That's brilliant. Um... yeah, no, it does... that was it basically. I don't have any more questions.	
05:13	A6	Okay.	
05:14	I	Thank you so much.	

TC	ID	Conversation	Gestures
05:14	A6	No, it's totally fine. Thank you for this. This is really nice. Like, the heat is just right.	A6 strokes the wearable prototype
05:22		And the thing I like about this one as well, walk up and run. [laughing]	A6 picks up the wearable prototype at the hem at her knee, lifts it up and unfolds it completely, holding it up in front of her.
05:26		Um, you have got the layers of heat, which is so you can have sort of a thin sheet of heat	A6 places the wearable prototype in its full size over her lap and legs. With her fingers she traces the heat strips, then moves her hands over her upper legs starting from the knees.
05:31		but then if you kind of fold these over themselves it kind of made a double heated layer	A6 picks the wearable prototype up by its hem and folds it in half towards her knees.
05:37	I	Yeah.	
05:37	A6	and I kind of liked having the option to build up the layers.	A6 picks up the upper hem of the wearable prototype and folds it back towards her upper body so there are three layers of it over the upper part of her upper legs.
05:41		So, this one, I really liked this one. [both laughing]	A6 lifts up the hem of the wearable prototype she was holding between her hands.
05:44	I	Okay. Thank you.	
05:45	A6	And it's covered a kind of wider body area than the pillow.	A6 lets go of the hem of the wearable prototype, lifts her hands and outlines the size of the wearable prototype in the air. She picks up the hem of the prototype again at her knees, holding it up and looking at it as it spans between her lap close to the upper body and her hands.
05:50		Um, just cause I think the heated things are just here but here you got like a wider area.	A6 lets go of the wearable prototype and turns towards the portable prototype to her left. She picks the portable prototype up with her left hand and points with her right hand along the heat strips of the portable prototype. She puts the portable prototype back down and turns to the front again. With her hands she outlines a rectangle in mid-air over the wearable prototype.
05:58		So, for all those reasons I prefer the sheet.	A6 picks up the wearable prototype by its upper hem, lifts it up to chin height and shakes it slightly. Then she puts it back down on her lap.
06:01	I	Okay. [A6 laughing] Okay great. Thank you so much.	
06:06	A6	No problem.	A6 lifts up the wearable prototype.

Participant A7

TC	ID	Conversation	Gestures
00:06	I	So, um, first of all, many thanks for, uh, for testing my prototypes.	

TC	ID	Conversation	Gestures
00:10	A7	You are welcome.	
00:11	I	And, um, I have some questions about how you used them. So, um, let's start with the, the cushion one.	
00:19	A7	Yeah.	
00:20	I	That's the one I gave you first. So how did you use it basically?	
00:25	A7	Ah, yes. So, it was just lying next to my keyboard	A7 turns slightly to the portable prototype lying next to him on the desk. He puts his left hand on the portable prototype.
00:29		and every now and then when I was tired from typing I would just... or talking to somebody... I would just put my hand on it and, um, that's it, I think.	A7 turns his chair to the left and moves on it towards the desk so he comes to sit at his desk. He lifts his hands and makes a typing movement in mid-air, then rests his palms on the desk with his hands up. He lifts his hands off the table and places his left hand and lower arm along the portable prototype lying next to him.
00:40		Um, at some point I tried to keep it next to the, to the track pad. But it was too, too high.	A7 moves the keyboard on the desk away and moves the portable prototype in front of him, slightly to the right. He puts his right lower arm across the portable prototype reaching his trackpad with his hand.
00:48		So, the whole thing was a little bit too big but that could be another use case.	A7 is lifting off his hands and arms and gesturing over the portable prototype. He places his right forearm again on the portable prototype and then touches it with his index fingers. He turns away from the desk.
00:53		So, yeah, I was just keeping it somewhere close to me on the table.	A7 turns back towards the desk and touches the portable prototype with both hands so the hands are at the ends of the prototype.
00:56	I	Okay.	A7 lifts his hands up.
00:57	A7	Okay, maybe sometimes, I was just really holding it like this. Again, we were talking. That's all.	A7 puts his hands back down resting them palm up on the portable prototype. He turns his hands, so his hands rest on the portable prototype palm down. Then he turns them palm up again resting them briefly in this position before turning his hands back palm down.
01:05	I	Okay.	A7 picks up the portable prototype and moves it to the left.
01:07	A7	Yeah, so.	A7 turns the chair back to face the interviewer while resting his left forearm on the portable prototype.
01:08	I	Okay. [A7 laughing] Yeah, that's not. Yeah, thank you.	
01:12		And then I gave you the other one.	A7 picks up and looks at a fold of the wearable prototype, which rests over the back of his chair. He plays with the fabric between his fingers.
01:14	A7	Yeah. So that one was most of the time on my chair and it was heating up my back.	A7 lets go of the wearable prototype and points at it briefly with the index finger of his right hand, his left forearm still resting

TC	ID	Conversation	Gestures
			on the portable prototype. He indicates towards his back with his right hand.
01:22		So that was the idea. Yeah.	A7 puts his right hand on his right upper leg and gestures with both hands without taking them up.
01:27	I	Okay. And, uh, when you had both of them available, which one did you use? And, uh...	
01:32	A7	I would say I used both of them. Well, I did not need to turn it on because it was warm.	
01:42		But yeah, maybe I was using the cushion just as a relaxation device rather than heating. Um, yeah, the shawl just was there. Maybe I wasn't using the shawl.	A7 is slightly turning left and right with his swivelling chair.
01:55	I	Okay. But if it hadn't been that warm, do you think you would?	
02:02	A7	I think then I would just turn it on and it would just be on.	A7 takes up his right hand and puts it back down on his right upper leg.
02:06		So clearly, because shawl doesn't require me actively putting a hand on it, then I would be using it more because I would just turn it on. Yeah, I would just be happier warm. [A7 laughing]	A7 takes his right hand up in front of his mouth, puts it down and points towards the portable prototype on the desk. He puts his hand back on his right upper leg.
02:19	I	Okay. Sounds good. Um... did you think about taking them with you at some point?	
02:27	A7	Um... actually, no, not really.	A7 shakes his head.
02:30		Like you mean, I don't know, to go downstairs for a coffee or something like this.	A7 gestures with his right hand. He lifts the left arm off the portable prototype and shifts his weight leaning back in his chair pushing his glasses slightly back on his nose with his left hand.
02:35	I	Yeah, or...	
02:35	A7	Well, if we had a sofa, which I really want to...	A7 is turning to his left and backwards on his chair and indicating with his left hand behind him. He turns back to the front, puts his hands in prayer position moving them up and down and looking upwards.
02:40		then I would probably take them with, with me. But, yeah... yeah.	A7 puts his hands down in his lap releases them and gestures with them briefly in the air before letting them rest in his lap.
02:50	I	Okay. Okay. Um, in one of the questionnaires, in the questionnaire you mentioned that, um, or suggested to have pillows in different shapes -	
03:03	A7	Shapes, yeah.	
03:03	I	sizes, and colours.	
03:05	A7	Colours.	
03:05	I	So, what were you thinking?	
03:08	A7	Yeah, I was, I was actually thinking about a trackpad, so it was a bit lower than...	A7 is pointing towards the trackpad on his table with his right hand. Then he lifts up his right hand in mid-air around shoulder height and lets it sink down a few inches.
03:14		I think I have it at home.	A7 lets his right-hand sink on his right upper leg, turns his upper body to his right and looks for something on his table.

TC	ID	Conversation	Gestures
03:16		It is basically maybe something like that high	A7 reaches with his left hand towards his monitor and picks up a packet of paper handkerchiefs lying there with his left hand. He takes it between both hands and holds it up in front of him.
03:19		and you are putting your, you are putting your wrist	A7 turns towards his desk, puts the handkerchiefs on the table and puts the wrist of his right hand briefly on the package his hand in the air.
03:22		and the idea is that you, your, your arm is relaxed.	A7 lifts his right arm up in the air, his right hand in line with his lower arm. He touches his wrist joint with his right hand.
03:26	I	Yeah.	
03:26	A7	And if that thing also generates heat, well.	A7 turns his right hand and lower arm, palm facing up and his right hand resting on his inner wrist.
03:31		And the colours, you know, they make things more colourful, funny. So pure aesthetics.	A7 gesticulates with both hands.
03:40	I	Okay. And, um, you mentioned in the comfort questionnaire that, um, you can't adjust the temperature. You try not to come to the office when it's cold.	A7 sits up on the chair.
03:56	A7	Yeah.	
03:56	I	Um, would any of the devices change this kind of behaviour? Do you think they would make you comfortable enough?	
04:07	A7	I am not sure because it's usually the feet, which get cold first. Um, hands as well, yeah, so it's basically feet and fingers.	A7 indicates towards his feet with his left index finger. He then opens up the hands, which he had folded in his lap.
04:18		But, uh, these particular devices...	A7 turns slightly to his left, looks and points towards the portable prototype on his desk and then to the right, towards the handkerchiefs and to and fro again.
		I am not sure. Maybe it works if you heat up your back and then the, the heat is being circulated through your body. But I am not sure.	A7 turns back to the front, takes his arms up, and then indicates with them towards his lower back. He then makes a circular movement with both hands in front of and along his upper body before resting his hands in his lap again.
04:34	I	Okay.	
04:39	A7	Yeah. But definitely would, yeah, I would use it much more if it was cold and I could put them somewhere to warm up. Yeah.	A7 opens up his hands in his lap, palms facing up. He then lifts his hands up into mid-air, palms facing down. He turns them again, so the palms face up and then puts them down into his lap again.
04:49	I	Okay. Then I just have a general question. Um, because here in the questionnaire it says... and I am not sure, I just wanted to know, because in this question here you said overall comfort in your workspace and to get your work done, if you answered this in more general terms,	The interviewer gets up, moves in front of the camera and stands next to the interviewee. She opens a folder and points into it.
05:15		like, if you think that the temperature is, like, good, thermal comfort is the most important	A7 takes the folder from the interviewer and takes a look inside. He looks up at the

TC	ID	Conversation	Gestures
		or if that was in relationship to your kind of, the, the conditions you experienced? Do you remember?	interviewer, looks back at the questionnaire and then puts the folder down on his lap.
05:33	A7	I think, well. So, from my point if it's too hot then it is impossible to work. And if it's too cold it is also really difficult. So, for me it's really important to get the right temperature.	A7 opens and closes the folder between his hands while talking.
05:49		So that's why.	A7 takes up the folder and looks inside again.
05:50	I	That's why you...	A7 looks up and puts down the folder.
05:51	A7	So, what I meant is that if the temperature is right then I'm more productive. If it's, if it's not then I'm just grumpy. [both laughing]	A7 gesticulates with his right hand while holding the folder open with his left. He takes it between both hands again and closes it.
06:02	I	Okay, okay, brilliant. Thank you very much. That was very helpful.	A7 hands the folder back to the interviewer. The interviewer takes it.
06:08	A7	Okay, cool.	
06:08	I	Thank you very much.	

Participant A8

TC	ID	Conversation	Gestures
00:02	I	Okay, so first of all, thank you very much again for testing my prototypes.	
00:04	A8	You are welcome.	
00:06	I	It's very kind. And, um, I have several questions about how you used them and, um, I think I would go straight in and, um, ask you like, how did you use them? I think I gave you this one first, but you said you weren't able to use it -	Interviewer puts the wearable prototype on the desk.
00:25	A8	Yeah.	
00:26	I	while you had it, it's	Interviewer moves the wearable prototype closer to the participant.
00:28	A8	U-um.	A8 reaches for the wearable prototype on the desk.
00:29	I	So, there is nothing to report maybe.	A8 holds the wearable prototype between his hands on the desk.
00:34	A8	But I used this one you gave both of them -	A8 slightly lifts some of the folds of the wearable prototype of the table
00:37	I	Yeah.	
00:37	A8	to me at the end of the study. I, I tried both of them.	A8 lets go of the wearable prototype and sits back in his chair.
00:41	I	Okay.	
00:42	A8	So, I can give you feedback on that one.	
00:43	I	Okay, yeah, so we will do that later. So, I am gonna, um, ask you how did you use this one when you had that one?	Interviewer hands the portable prototype to A8. A8 takes it with his right hand.

TC	ID	Conversation	Gestures
00:52	A8	So, I used this mainly at my back because it was really convenient to use, to use here.	A8 holds the portable prototype briefly between both hands then holds in his right hand and finally places it at his lower back, holding it in place behind his back with both hands.
00:59		And... I also, I, I, really liked to like, uh, keep my hands on this when I am like watching something or reading.	A8 takes the portable prototype from behind his back and holds it up in front of him shifting it and turning it between his hands.
01:07	I	Yes.	
01:08	A8	So, I put it on my lap and I put my hands on it, like this.	A8 puts the portable prototype across his lap and puts both of his hands, palm down, on it. He lifts them off briefly and puts them back down.
01:12		Cause like in winter or if I feel cold generally my hands are super cold not my body, so I try to keep my hands warm.	A8 lifts off his hands from the portable prototype, turns them palms up, rests them down and then lifts them into mid-air, turns them palm down wriggling his fingers and then palm up again. He makes a sweeping movement with both hands towards his upper body and rests them back down on the portable prototype before lifting them up again.
01:23		So, I use like this or on my back.	A8 grabs the portable prototype with both hands lifts it up and lets it fall back down on his lap. He grasps it with his right hand and moves it towards his back and back again.
01:29		But other than that, I couldn't find a really like, um, like better way to use it.	A8 holds the portable prototype briefly between both hands in front of him, then shifts it into his right hand and makes a juggling movement with both hands.
01:34		Sometimes my feet are cold, but I didn't use [A8 laughing] on my feet so. Yeah.	A8 shifts the portable prototype into his left hand and indicates with his right hand down his right leg towards his foot. He again holds the portable prototype in both hands briefly, shifts it into his right hand, and briefly points it towards his right foot. He places it back in both hands looking at it. He turns it and puts it across his lap.
01:41	I	Okay, no, that sounds good. Thank you very much. So, and, um, then when you had both of them available. So how did you use them and -	A8 picks up the prototype with both hands, holds it briefly looking at it, and places it on the table with his left hand.
01:51	A8	So	A8 reaches for the wearable prototype on the desk and holds it with his right hand.
01:51	I	which did you use?	
01:52	A8	Since I tried this before, I decided to give this one a go.	A8 lifts the portable prototype off the desk with his left hand and puts it down again. He takes up the wearable prototype with both hands and starts unfolding it.
01:59		So, I used this like as a cape. So, I put, put it like on my back. Like this. C39	A8 takes the wearable prototype off the table and fully unfolds it in front of his body, holding it up. He swings the wearable prototype around his shoulders, so it falls over his shoulders and covers his back.

TC	ID	Conversation	Gestures
02:05		And it was really nice. It was really, uh, comfy and it's not heavy. So, it is like super convenient.	A8 rearranges the part of the wearable prototype around his neck and shoulders. He touches the ends at his shoulders with his hands. Then he adjusts the cloth at his back slightly with both hands, pulling it in place.
02:13		So, this, this one actually is a bit better than this.	A8 leans slightly back in the chair, shifts his gaze towards the portable prototype on the table and reaches for it, picks it up, and places it back down with his left hand. He touches the fold of the wearable prototype over his right shoulder with his right hand. He briefly lifts off the portable prototype on the table and puts it back.
02:19		Because this just... if, if I put this on my back this just gives heat to like a little portion my back.	A8 picks up the portable prototype with both hands and moves it towards his lower back with his right leaning forward with his upper body while doing so. He brings it back to front, holds it with both hands for a moment, lets it come down on the table and reaches for his lower back with his right hand, followed by his left to indicate the lower back area.
02:26		but this covers whole back part of my body, so this is a bit nicer.	A8 brings his hands up touching the wearable prototype at his shoulders briefly, and then moves his hands first up and then down along his body, reaching back to touch his back and indicating an area around his waist level. He brings his hands back up taking the wearable prototype between his fingers at the shoulder level. He leans back in the chair.
02:31		And this, this one is also, like I can use on my lap like this or I can keep my hands on it.	A8 briefly lets go of the wearable prototype then grabs it again and brings it to front from around his shoulders with the right hand. He places it over his upper legs with both hands, so it falls down over his knees and the sides of the legs. He puts his hands on respective upper leg.
02:39		So, this is actually much more, uh, like flexible than this, I think.	A8 picks up the wearable prototype with in its midst between the fingers of both hands and lifts it slightly off his upper legs. He lets it slide back and taps the portable prototype on the table with his left hand.
02:44		Yeah, I think, if I, if I would, um, have a like option, I would take this one, except that.	A8 gathers up the folds of the wearable prototype between his fingers, holding it up in front of him while doing so and moving and turning it.
02:54	I	Okay. So, when you had both available, did you use both? Or just...	A8 places the wearable prototype on the table next to the portable one.
02:59	A8	No, I used this one.	A8 puts his right hand briefly on the wearable prototype.
03:00	I	Only that one. Okay. And, um, because I only gave you one battery, so you only could use one at a time.	A8 puts his hands in his lap.
03:08	A8	Yeah [A8 laughing]	

TC	ID	Conversation	Gestures
03:08	I	If it had been possible, would you have used both of them at the same time?	
03:12	A8	I wouldn't use both of them because I'm not like... our office environment is not super cold. I wouldn't probably need an...	A8 gestures with his hands.
03:23		as I said, I just need to keep my hands warm.	A8 lifts up both hands, palms up.
03:26		If, if this does the job, I wouldn't need another one.	A8 reaches for the wearable prototype on the table, picks it up with his right hand, and holds it briefly between both hands, and places it back on the table with his right hand.
03:30		Like, um, like it's too much to, like batteries and stuff so this one is enough.	A8 gestures with his hands, places them back on his upper legs and lifts them back up moving them left to right. He reaches for the wearable prototype with his right hand, lifts it up briefly, and puts it back down.
03:39	I	Okay. That's fine. Okay, thank you. And, um, did you think about taking the prototypes with you at some point? Or would you have liked to?	A8 puts his hands in his lap.
03:50	A8	Um... no. Uh, I wish there was something I could use on my bike, but I wouldn't take that risk to damage your prototypes, so I didn't.	A8 gestures slightly with his hands and indicates slightly towards the prototypes on the table with his hands under the desk.
03:59		I didn't try that but, uh, sometimes in like winter, the weather is super cold and even if you wear gloves it is not enough.	A8 touches the wearable prototype briefly with his right hand and then takes his hand up towards his forehead. He holds both hands up in front of him, palms up.
04:08		So, I wish there was something that could heat my hands, like on the bike.	A8 puts his hands in his lap. He lifts his hands back up and touches his left with his right hand moving his right thumb from the wrist to the palms of the left hand and then his right hand with his left, moving the left thumb from the palm to the wrist of his right hand. He puts his hands back down in his lap.
04:13		Uh, but I, I didn't take any of them at home or something. I just used them in the office.	A8 briefly lifts his right hand up and puts it back down. He repeats the gesture.
04:19	I	Okay, okay. And, um, so in the questionnaire you mentioned that you like the idea of, um, the pillow and, um, heating and you suggested to have a flexible heating element, if I understand that correctly, to use with different sizes of pillows -	
04:39	A8	Uh-um.	
04:39	I	Uh, did you have any specific sizes in mind, or how this would be?	
04:46	A8	Uh, at that time I didn't, uh, I didn't use this one.	A8 reaches for the wearable prototype and moves it between both hands.
04:51		So, I was just thinking to like, how this can be improved.	A8 reaches for the portable prototype and holds it between both hands, moving it between them. A8 puts the portable prototype on the table and puts his left hand on it briefly.

TC	ID	Conversation	Gestures
04:56		Uh, so I thought if there was a like, if these strips, uh, are flexible, if these were flexible...	A8 takes the beginning and end of one of the heating strips on the cover of the portable prototype between his fingers and lifts it off slightly. He lets it go and picks it up again.
05:04		I mean you could fit this thing to another like other pillows.	A8 picks up the portable prototype with both hands at its ends, puts it down at the table again and pushes it slightly down with his hands. He lets go of the prototype and gestures in mid-air above the prototype.
05:08		Or you can stretch them to your needs. Like I was just thinking about that.	A8 briefly touches the portable prototype with his left hand, then makes a stretch gesture in mid-air by making a fist with his hands and moving them away from each other.
05:13	I	Ah, yeah, okay. So, and, um, after you used the other one do you have any suggestions for this one?	A8 rests his hands in his lap, then reaches for the wearable prototype with his right hand.
05:23		I think this is like pretty straight forward and it's, it's better to, better not to have this as a like a sweater, something that you can put your arms in.	A8 lifts up the wearable prototype with his right hand, holds it for a moment and then puts it back down on the table with both hands. He then starts unfolding the wearable prototype and holds it up in front of him. He turns it slightly, so the sensing circuit is at his right hand and continues letting it unfold. He puts it down on his lap. He lets go of it and moves along his left arm with his right hand and along his right upper arm with his left hand.
05:37		So, this is just like a piece of, uh, like fabric.	A8 picks up the wearable prototype from his lap and holds it up in front of him, above his head, before lowering to chest height.
05:41		That's, I think that's the nice thing about this because you can use it as the way you want it.	A8 lowers the wearable prototype, let's go of the corner he was holding with his left hand, takes the corner he was holding in his right hand into his left and lets his right hand slide along the hem towards the next corner. He shakes the prototype slightly.
05:48		It does not limit you to wear or do something.	A8 lets go of the wearable prototype and lets it fall into his lap. He makes a wrapping movement with his hands and shoulders.
05:51		You can, I don't know, fold it, do, or sit on it or everything. So, I think, this is like pretty like simple. That's why it's better. Yeah.	A8 picks up the wearable prototype again, starts folding it to a scarf, and puts his hands closer together to form a loop. He points towards the chair underneath him with his left hand and then places the wearable prototype back on the table.
06:02	I	Okay. Okay, thank you.	
06:04	A8	You're welcome.	
06:04	I	That were all the questions I had. So that's it.	
06:07	A8	Alright.	
06:08	I	Thank you again.	

Participant A9

TC	ID	Conversation	Gestures
00:05	I	And, um, first of all thank you so much for participating in my study and for testing the devices.	
00:11	A9	I am glad I use it, it is very good equipment.	
00:13	I	I am glad to hear that actually. So, um, I have several questions and, uh, yeah it would be great if you could answer them.	
00:22	A9	Go ahead, please.	
00:24	I	Yeah. So, um, I first gave you this prototype and I -	Interviewer hands the portable prototype to the participant.
00:27	A9	Yeah.	A9 takes it and holds it between both hands.
00:27	I	would like to know, um, how you used it.	
00:30	A9	Um, for this one, I just put in my legs because, uh, for me, uh, the top of my body half part feel very warm.	A9 moves the portable prototype between her hands, turns it and puts it across her lap, slightly pushing it down with both hands. She lifts her hands up towards her shoulders and moves them up and down several times in mid-air along her upper body.
00:39		As you can see, I always wear some short sleeves. But my legs sometimes feel very cold.	A9 stretches out her right arm and moves her left hand up and down her right arm. She bends slightly forward and indicates towards her legs by moving her left hand down towards her left lower leg.
00:46		So, I just put it in my legs.	A9 sits back upright and takes the portable prototype between her hands. She places it down on her lap and slightly pushes it down with both hands.
00:48	I	Yeah.	
00:49	A9	So very simple. [A9 laughing]	A9 takes up the portable prototype in the middle.
00:51	I	Yeah.	
00:52	A9	Sometimes just hold it.	A9 turns the prototype and presses it against her upper body, embracing it with both arms.
00:54	I	Okay.	
00:54	A9	Yeah. But I think this one if it will be bigger, like a cushion, it might be better.	A9 releases the portable prototype and keeps it briefly between her hands in front of her, looking at it. Then she places it back down across her lap, her hands, palm down, on top of it. She picks it up again in the middle, holds it up in front of her and slowly shakes it right and left, turns it back down and places it back on her lap.
01:02	I	Okay, like, uh, which kind of size?	
01:04	A9	I mean like this size like we use it in the car.	A9 lets go of the prototype and with index fingers and thumbs of both hands creating its corners, spans a rectangle in mid-air, about 40cm by 40cm in size. She holds the right hand up and left hand down first for upper right and lower left corners, before switching the hands, so left hand is up, and right hand is down. She switches hand

TC	ID	Conversation	Gestures
		So, yeah.	positions a second time, so right hand is up and left hand down again. Then she takes both hands down and indicates towards her lower back with the left hand. A9 briefly indicates the size in mid-air again with her hands, marking all four corners by switching her hands up and down.
01:09	I	Ah!	
01:10	A9	So, you can put it on the back of your, your back and also put it on your legs. Yeah.	A9 picks up the portable prototype and puts it and holds it behind her back, about mid-way between upper and lower back, with both hands. She brings it back to front with her left hand, places it on her lap, and softly pushes it down with both hands.
01:17	I	Okay. Yeah, thank you. Okay, sounds good. Um... and then I gave you this one.	The interviewer holds out the wearable prototype. A9 picks up the portable prototype and they exchange the prototypes.
01:23	A9	This one.	A9 takes the wearable prototype with her left hand.
01:24	I	Yeah.	
01:26	A9	Uh-um. This one have two ways of use them.	A9 holds and moves the wearable prototype between both hands. She unfolds it.
01:30		One way is just wear, uh, shall I, wear it like, like a scarf.	A9 holds up the wearable prototype by one of its corners with her right hand and tries to move it across her shoulders. She does not get the right hold with her left hand and briefly lowers the wearable prototype and puts her right hand back up. She places the wearable prototype across her shoulders, so it falls down her back.
01:35		So, when I'm working.	A8 lets go of the corners of the wearable prototype handing down her shoulders. She picks them up again and adjusts the position of the prototype on her shoulders.
01:38		But, uh-uh, for me, ah, some, some come from the back of my body. So sometimes very hot.	A8 continues arranging the folds of the wearable prototype over her shoulders. She points towards the back of her body with her hands.
01:45		So, uh... most of time I just put it in my legs.	A9 removes the wearable prototype from her shoulders by pulling it with her left right hand over her left shoulder. She puts the wearable prototype over her upper legs, so it falls down at the sides and over her knees.
01:50	I	Okay.	
01:51	A9	[A9 laughing] So most of my work is just programming. So that's it. [A9 laughing]	A9 turns her body and the chair towards the laptop on the desk next to her. She puts her palms on the palm rest of the laptop keyboard and starts typing with her fingers in the air. She lifts off her hands and shrugs.
01:57	I	kay, cool. And then, um, you had both of them available, so which -	The interviewer gives the portable prototype to A9. A9 picks up the wearable prototype from her lap and holds it in her right hand. She takes the portable prototype with her left.

TC	ID	Conversation	Gestures
02:01	A9	Yes.	
02:01	I	one did you use, or did you use both?	A9 holds the prototypes in her hands briefly
02:03	A9	Uh... I used both. But I think both of them are very useful. That depends on the weather, the condition that you use them.	A9 looks at the prototypes in her hands and starts turning the portable prototype in her hands. She moves both prototypes slightly in her hands while she gestures.
02:13		But if I only one option, I choose this one because... uh-uh... I think the area is larger.	A9 holds up the wearable prototype with her right hand. She unfolds the wearable prototype using the left hand, in which she is still holding the portable prototype. She holds the wearable prototype in front of her and lets it slowly sink down on her lap.
02:20	I	Yeah.	
02:20	A9	Yeah.	
02:22	I	So, and then in which situation did you use the, the cushion?	A9 folds the wearable prototype together. She is holding it in her right hand again. She lets both hands with the prototypes sink down on her lap.
02:25	A9	Um, the cushion. Uh, the same condition with the scarf, I just put it on my legs.	A9 looks at the portable prototype in her left hand and turns it slightly. She places the wearable prototype on the desk next to her with her right hand. She puts the portable prototype across her legs and pats it with her left hand. She briefly reaches for the wearable prototype on the desk and touches it with her right hand. She puts both hands on the portable prototype and rolls it slightly forward and backward.
02:35	I	Yeah, yeah. But you mentioned that it depends on the weather.	
02:40	A9	Yeah.	
02:41	I	Yeah, so when would you use the cushion?	
02:44	A9	Uh...	A9 briefly lifts her finger off the portable prototype and then lets them fall back on it again. She then lifts both her hands and shrugs before placing them back down.
02:48		Most of the time I used the scarf but for this one my legs feel cold, yeah.	A9 briefly touches and lifts the wearable prototype on the desk next to her. Then she takes the portable prototype between her hands and lifts it up. She shifts it into her left and strokes her right leg with her right hand.
02:53		Because I can't put it in somewhere else like the scarf. I can only put it in my legs.	A9 moves and turns the portable prototype between both hands, looking at it briefly. She keeps holding it in her left hand and grabs the wearable prototype on the desk with her right hand briefly. Then she puts the portable prototype across her legs with both hands.
02:59		And for me, most people like to sit totally in their chairs.	A9 holds the portable prototype with her right hand and grabs hold of the arm rest of the chair with her left hand. She moves her upper body forward, sits back in the chair with her back touching the backrest, and lifts the portable prototype off her lap while doing so, holding it in her right hand.

TC	ID	Conversation	Gestures
03:05		But I play a kind of instrument. So, I used to just sit a third of the chair.	A9 moves her upper body away from the backrest. She lifts her arms and hands into mid-air, as if holding an instrument between them, the portable prototype still clutched in her right hand. She gets up from the chair, still in an extended sitting posture, slightly turning around to draw a line at the first third of the seat with her left hand.
03:11		So, I will never touch the, the back of the chair.	A9 sits down at the front of the chair and moves her upper body back until it touches the back of the chair. She rests in that position, her upper body in diagonal, briefly and taps the backrest of the chair with her left hand. The portable prototype in her right hand comes to rest on her lap.
03:16		So, for me, I can't put it here.	A9 adjust her sitting position on the chair and sits back, placing the portable prototype at her lower back, between her back and the backrest of the chair.
03:19	I	I see.	
03:19	A9	Yeah, just depends on person.	A9 removes the portable prototype from behind her back and brings it to the front using her left hand. She holds it in front of her and looks at it.
03:21		But for most people, my colleagues, when they coding they prefer sit like this. So, they can put the cushion back.	A9 shifts the portable prototype to her right hand. She sits back in the chair supporting herself against the armrest. She leans back in the chair, her right hand holding the portable prototype up in mid-air. She lifts both hands up. Then she puts the portable prototype behind her back, at about mid-back height, holding it there with both hands before leaning back and letting go of both hands. She slightly adjusts the position of the prototype, pulling it an inch down with her fingers before leaning back again.
03:30	I	I see.	
03:31	A9	Yeah.	A9 leans forward with her upper body and grabs hold of the portable prototype with her left hand.
03:31	I	I see, okay.	A9 moves forward and brings the portable prototype forward.
03:32		[A9 laughing] Thank you for explaining. Um, would you have used both at the same time if you had, if that had been possible, like, um, both together?	A9 puts the portable prototype across her legs, placing both her hands-on top of it. A9 nods.
03:45	A9	Um... I never use that, but it is a good idea.	A9 gestures with her fingers, her palms still resting on the portable prototype. She then rests both hands again on the prototype.
03:49	I	Would you have because you couldn't because I only gave you one battery.	
03:54	A9	Oh, yeah. Well, I think I can if I am extremely cold.	A9 lifts her hands and indicates shrugging something over her shoulders. Then she rests her hands back on the portable prototype across her lap.

TC	ID	Conversation	Gestures
04:01	I	Okay. And, um, did you think about taking the prototypes with you when you left the office?	
04:07	A9	Yes.	A9 starts nods.
04:09	I	So, did you take them? Or?	
04:11	A9	No, because the sensor and, um, the microprocessor is at my table, so I think it's better for leave it in the office. Yeah.	A9 shakes her head. She briefly touches the wearable prototype on the desk with her right hand and gestures with both hands. She slightly turns towards the desk on her right and forms the outline of the sensor node on the table with both hands. She turns back to front and points briefly towards the wearable prototype. Then she rests her hands and forearms on the portable prototype in her lap.
04:19	I	Ah, okay. Um, but you would have liked to take it? Or?	
04:24	A9	Um, yes. So, it is not very heavy.	A9 picks up and lifts the wearable prototype with her right hand and then also lifts up the portable prototype with her left hand. She nods and then places the prototypes back down.
04:32	I	Okay, cool. Um, and you mentioned in the questionnaire that you're, um, so how I understood it was that your body adjustment to the environment, um, your ability of, the, the ability of your body to adjust to the environment became weaker	A9 puts her hands back on the portable prototype in her lap.
04:52	A9	Yeah.	A9 nods.
04:53	I	So, could explain a bit more what you mean?	
04:56	A9	Uh, yeah, uh, I'm not really totally understand that question.	A9 lifts her hands up, turns them palms up, then palms down again, and places them briefly on the portable prototype before lifting them back up, palms down and fingers spread, moving up and down slightly
05:00		Uh, let's say, for example, I like to drink hot water. But if I always drink hot water when I drink the normal temperature water, I will feel "oh, it's so cold!" but it isn't.	A9 gestures with her hands in mid-air.
05:13		So, if, uh, when I feel cold, I use this one, I use this prototype and when it's normal temperature, I may feel cold.	A9 rests her left hand on the portable prototype and picks up the wearable prototype with her right hand. She holds up the wearable prototype in front of her with both hands. She puts it back down on the desk and then indicates with both hands along her upper body by moving them up and down quickly on both sides of it.
05:22		So, I think that explain why I write I feel more sensitive.	A9 gestures in mid-air. She makes a writing gesture with her right hand. She then rests both hands on the portable prototype.
05:27	I	Ah, yeah. Okay, yeah. And, uh, thank you very much. [A9 laughing] And the last question, um, is that, um, I mean you already explained. It was about the cushion prototype	

TC	ID	Conversation	Gestures
05:39	A9	Yeah.	A9 lifts the portable prototype holding it between both hands.
05:40	I	Because you also mentioned in your questionnaire, um, that a shortcoming was the shape of it. I mean, you already explained that it could be larger. In the questionnaire you mentioned it could be a belt.	A9 puts it back down on her lap and rests both hands on it. A9 is nodding.
05:53	A9	Yes.	A9 nods.
05:55	I	So, um, what were you specific thinking of? Could you show or explain how this belt would look like?	A9 takes up her hands and touches her hair.
06:05	A9	I think this belt will look like a, um, coultter of the scarf, like this one.	A9 picks up the wearable prototype and moves it onto her lap. She tries to fold it up then unfolds it again, holding it briefly up in its full width, then gathering it up along its length. She holds it folded up in front of her briefly, then wraps it around her belly, holding its ends together in the back.
06:14		I don't know but in China when the girls is in her period, they prefer to put something hot in their belly to release the pain.	She lets go of the wearable prototype with her left and brings it back to front and up with her right hand. She continues holding one end with her right hand while the rest of it rests on her lap. She strokes her belly briefly in a circular movement with her left hand. She then moves her left hand up and down next to her lower upper body.
06:24	I	Yeah.	
06:25	A9	So, in China we have some product but not, uh, as, uh, light as this one	A9 picks up the other end of the folded wearable prototype with her left hand. She holds, moves, and turns the wearable prototype between her hands. She gathers it briefly in her right hand.
06:31		so, we put a very heavy bag and can heat by itself in the belly. [A9 laughing]	A9 spreads out the folded wearable prototype again between both her hands. She moves it towards her belly briefly, then puts it back on the table and forms an approximately A6 size object with her hands in mid-air in front of her belly. She touches her belly and keeps both hands resting between waist and thigh.
06:36	I	Ah, okay. I didn't know. [both laughing] That is very interesting.	A9 puts her hands back on the portable prototype in her lap.
06:40	A9	That is another, um, product, yeah -	A9 lifts her hands up briefly, palms facing up, and places them back down, palms down.
06:43	I	Yeah, ah, I see.	
06:45	A9	It is also useful when you want to part of your body be, uh, warmer.	A9 lifts her right hand, palm up. She lifts her left arm up and moves her right hand up and down her lower left arm.
06:50	I	Ah, okay.	
06:51	A9	It's like an ice bag but it's a warm one. Opposite way of the ice bag. [A9 laughing]	A9 forms a brick size, rectangular area between her hands in mid-air. She indicates towards her lower left arm and then makes a turn over movement with both hands. She forms a rectangle again between both hands.

TC	ID	Conversation	Gestures
07:00	I	Sorry, what was the last word?	A9 rests her hands on the portable prototype
07:03	A9	I said, I mean, uh-uh... a bag of ice.	A9 forms a rectangle with her hands in mid-air, then rests her hands back on the portable prototype.
07:07	I	Oh, ice bag!	
07:08	A9	Yes.	
07:08	I	Oh sorry, yes! Now I get it. Okay, and, um, before we're done, I have to follow up question because, um, so... in comparison to the belt how does the wearable prototype fare?	
07:24	A9	Um... I think this one is better. Because my mum very painful about his back.	A9 lifts up the wearable prototype from the desk slightly and places it back down again. She moves her hair out of her neck with her left hand and touches and moves along her neck/upper back area with her right hand.
07:30		I think it's for everyone. If she or her, he walk and sit down and play a computer.	A9 continues to pat her upper back/neck area, then holds her hands in mid-air gesturing and imitating a typing movement with her fingers. She lets her hands fall on the portable prototype in her lap, lifts them up briefly, and lets them fall back down.
07:37		So, um, if you got one that warm your neck maybe, I think, for my mum, she neck pain release. Yeah.	A9 picks up the wearable prototype, which is still folded, and puts it around her neck. She adjusts her hair and pats the wearable prototype falling down her neck at about shoulder height.
07:47	I	Okay, cool. Brilliant so those were the questions I had. Or, maybe, can I ask one more?	A9 removes the wearable prototype from around her neck. She holds it in her hands, which she rests on the portable prototype on her lap.
07:54	A9	Of course -	A9 lifts up her right hand, palm up.
07:55	I	Because it came to my mind just now. So, um, how did you feel about wearing them in the office or using them in the office? Did you feel okay with it?	
08:05	A9	Yeah, I feel okay. And I write comments about the appearance. I think it should be a little bit pretty.	A9 lifts up the wearable prototype and holds it in both hands, looking at it. She unfolds it, so it spans, still folded across its length, between her hands. She moves it between both hands, adjusting the distance between her hands it spans across.
08:13		I am not means I want it to be really pretty, I mean, if I use it I won't everybody ask me "What are you using?" [both laughing]	A9 gathers the wearable prototype up and holds it in her hands. She unfolds it again and folds it back together. She gestures with her right hand and lets her left hand, which is holding the prototype, sink in her lap.
08:21		I just it look like a normal scarf or it look like a normal cushion. Yeah.	A9 picks up the wearable prototype with her right hand and holds it up before placing it on the desk next to her. She shifts her gaze to the portable prototype in her lap and picks it up with her left hand. She holds it briefly up before placing it back down in her lap and putting her hands on it.
08:27	I	Okay.	

TC	ID	Conversation	Gestures
08:27	A9	And it has an extra function.	A9 picks up the portable prototype with both hands, holding it up in front of her.
08:30	I	Yes, I see. Okay, thank you. Thank you very much.	A9 places the portable prototype back down on her lap and puts both hands on it.
08:34	A9	Any questions.	
08:35	I	No, that's it. Thank you very much for your help.	
08:38	A9	You are welcome.	

Participant A10

TC	ID	Conversation	Gestures
00:12	I	First of all, thank you very much, again -	
00:14	A10	That's fine.	
00:14	I	for testing my prototypes. And, um, I have, yeah, I would like to know how you used them basically and, um, maybe we could start with this one: the wearable one. Could you please show me how...	The interviewer hands the wearable prototype to A10. A10 takes it and unfolds it, holding it up in front of him.
00:31	A10	I just put it over my legs. I just had it like that because it was under the desk and nice and yeah.	A10 sweeps it over his upper legs, so it falls down at the sides of his legs and over his knees. He rearranges the fabric moving it slightly over to his left. He puts his hands in his lap. Then he turns to his left on his chair towards his desk and back again. He shrugs with his shoulders slightly.
00:39	I	Okay.	A10 looks down on his legs.
00:40	A10	Yeah.	A10 nods his head.
00:42	I	Okay, thank you. And then you had this one for two days. How did you use this one?	A10 folds his hands in his lap. The interviewer hands the portable prototype to A10 and they exchange prototypes.
00:48	A10	This one, basically, I put it there.	A10 holds the portable prototype briefly between both hands then puts it behind his lower back with his left hand, slightly leaning forward with his upper body and then leaning back in the chair.
00:52		Because I tried it on, I had it on my lap and it did not feel right, didn't make sense to me	A10 takes the portable prototype from behind his back and puts it on his lap, along his upper legs, with his left hand. He indicates with his hands towards his desk on the left.
00:57		and I've got like tall I don't have much space under the desk either.	A10 turns towards his desk, lifts the portable prototype with his right hand and touches his left leg with his left hand. He turns back to front touches his left leg again, and then both his legs briefly with both hands, letting go of the portable prototype in his lap.
01:01		And so, I thought the first few minutes I really did not know what to do with it	A10 takes the portable prototype with both hands and rearranges it on his lap, putting it across his upper legs and turning it slightly.

TC	ID	Conversation	Gestures
			He lets go of the prototype and rests his arms on the armrests. He briefly picks up the portable prototype again with both hands and moves it, so it comes to lie at 90 degrees across his upper legs. He links his fingers in front of his belly, behind the portable prototype.
01:06		and was very like “no, this isn’t right I won’t get it fully down” and once I put it there it was really nice. I liked it there.	A10 shakes his head and unlocks his fingers. He puts the sides of his hands briefly across the portable prototype on his lap. He then picks up the portable prototype, holds it up in his right hand, leans slightly forward with his upper body and points towards his lower back with his left hand. He leans back again, crosses his legs and holds the portable prototype between his hands.
01:14	I	Okay, cool. And, um, and then you had both available. So which one did you use, or did you use both?	The interviewer hands the wearable prototype to A10. A10 takes it with his right hand while holding the portable prototype in his left.
01:23	A10	I used this one.	A10 holds up the wearable prototype.
01:25	I	Okay.	
01:25	A10	Because... So, it was actually, it actually got quite cold. It got quite nasty [A10 laughing].	A10 keeps holding the wearable prototype in his right and the portable prototype in his left hand, moving them slightly as he speaks.
01:30		Um, but I, I used this one cause, cause this one was more about making me warm,	A10 raises his hand holding the wearable prototype and moves it slightly to and fro.
01:38		whereas this one, this one was making me comfortable, which I know that seems odd to distinguish and I don’t know quite how doing it.	A10 lets his right hand with the wearable prototype drop by two inches while lifting up his left hand holding the portable prototype. He puts the wearable prototype down on his lap and rests his right arm on the armrest. He continues holding up the portable prototype with his left hand, moving it slightly as he speaks.
01:46		This one I kind of get bad back and it was really nice to have it there to have a little bit warmth here, but I didn’t think it necessarily stopped me being cold, if you see what I mean.	A10 shifts the portable prototype from his left to his right hand, leans forward and points towards his lower back with his left hand and moves it slightly up and down his lower back. He brings his left hand back to the front and gestures with both hands, the right still holding the wearable prototype.
01:58	I	Yeah.	
01:59	A10	It was nice to have there but it wasn’t like “Actually, this room is cold and now I don’t feel cold”, whereas this one heated me up.	A10 continues gesturing with his hands. Then he pats the wearable prototype on his lap with his left hand.
02:05	I	Okay. Okay, I see. Okay, I totally understand the difference. Okay and, um, because you could only use one at a time, cause there was only one battery, um if you could have used both at the same time, would you have done so?	A10 holds up the portable prototype between both hands and moves it around between them.
02:19	A10	Um, possibly. Yeah. I feel, quite luxurious [both laughing]	A10 keeps holding the portable prototype between both hands.

TC	ID	Conversation	Gestures
02:27		Yeah, I mean, to be honest, like, I, I could have that most days.	A10 turns the portable prototype between his fingers and holds it up resting its ends on the fingers of both hands.
02:31		I stole this in the hallway because, because it is quite nice.	A10 shifts the portable prototype to his right hand and reaches underneath his desk with his left hand. He brings it back holding up a square, lilac cushion. He throws it back under the desk and reaches towards his lower back with his left hand.
02:38		I mean, if I am here for a long time and I am slouching, you know, it's nice to have something there, which I am often.	A10 rests his left hand on the armrest and slouches in his chair. He then sits up straight in his chair and reaches with his left hand towards his lower back and briefly moves it up and down the lower back area.
02:46	I	Yeah.	
02:46	A10	So yeah, I probably would.	A10 briefly puts down the portable prototype on his upper legs before lifting it up with his right hand and touching the wearable prototype on his lap with his left hand.
02:50	I	Okay. And, um, did you also think about taking the devices with you? Like when you	A10 puts the portable prototype back down on his lap holding it between his hands.
02:59	A10	No.	A10 shakes his head.
03:00	I	were going somewhere else.	
03:02	A10	No.	
03:03	I	Okay.	
03:04	A10	Yeah.	A10 slightly lifts up the portable prototype between his hands.
03:05	I	Okay. Did...	A10 puts the portable prototype back down on his lap.
03:07	A10	I mean to be honest if I am, if I am either here or I am going out, getting lunch, coming back. It is not like I sit somewhere else somewhere.	A10 lifts his left hand up and touches his desk with his left index finger. He then points it up, then to the door, and then to the back. He briefly rests his left arm on the armrest before making a sweeping gesture with his left hand. He then rests his left arm back on the armrest.
03:15	I	Yeah. Okay, cool. And, um, one more question. In the questionnaire you mentioned that, um, when you used the wearable, the blanket prototype, um, that you noticed that your hands were cold?	
03:35	A10	Yes.	
03:36	I	And, um, that the prototype nevertheless helped because there were drafts.	
03:42	A10	Yeah. Yeah.	
03:43	I	Um, um, can you explain to me how the prototype helped?	
03:50	A10	I mean it just generally made me, it, you know, it took the edge off. Although it wasn't, you know. I thought the hands separated.	A10 shifts in his chair and puts the portable prototype on a cupboard in front of him. He leans back in his chair and links his fingers in front of his belly. He takes his hands up, his left hand in his right first, then covering his right hand with his left, and finally opening them up, fingers spread.

TC	ID	Conversation	Gestures
03:59		I hadn't realised how, like it was my hands that would get cold -	A10 makes fists, holding them up first, then putting both fists together.
04:02	I	Yeah.	
04:03	A10	until I'd start to do something about it and that.	A10 releases his fingers and points with both hands down onto the wearable prototype on his lap. He gestures briefly with his hands and puts them together in front of him.
04:09		Um... but it's still it just kind of made me feel nicer, although I was aware that the, the chill was on my hands.	A10 lowers his hands down on his lap but butts them back up again, stroking his left hand with his right briefly, before keeping them up in front of him like this, the right hand in front of the left.
04:18		Then still having my kind of ambient temperature just raised slightly was nice.	A10 gestures with his hands briefly, then puts them back together.
04:24	I	Okay.	
04:25	A10	Yeah.	
04:25	I	Okay, cool. Okay, thank you. That was it already. Thanks a lot.	

Participant A11

Participant asked not to be filmed.

TC	ID	Conversation
00:02	I	First of all, thank you very much again for testing my prototypes -
00:04	A11	You are welcome. Sure.
00:06	I	That was very kind of you and, um, I have, uh, a few questions regarding, in regard to how you used them.
00:14	A11	Uh-um.
00:14	I	So, if I remember correctly, I gave you the portable prototype first.
00:18	A11	Uh-um. Yes.
00:20	I	I have got it here just because it is easier to see it to see stuff to talk about it. And, uh, I would like to ask you, how did you use it and, um, if you could please explain to me?
00:33	A11	Basically, so the way I used it, uh, so I used it in, for my back. What is this part called? My waist?
00:44	I	Um?
00:44	A11	The waist, the curve here?
00:46	I	Um... the lumbar, I think, spine. It's -
00:50	A11	Yeah.
00:50	I	the lower back.
00:51	A11	Yeah, lower back, yes. Uh... the heat because after the gym I had a little bit pain there. So, I, so the heat was helping me. So -
01:00	I	Yeah.
01:01	A11	So that was the main way of, the main way I used it. The other way was that I used it on my, the handle of my chair, on my chair putting my hand on it. I feel, like, uh, posh.
01:14	I	Okay.
01:16	A11	But yeah...
01:16	I	Okay. Can I ask you quickly -

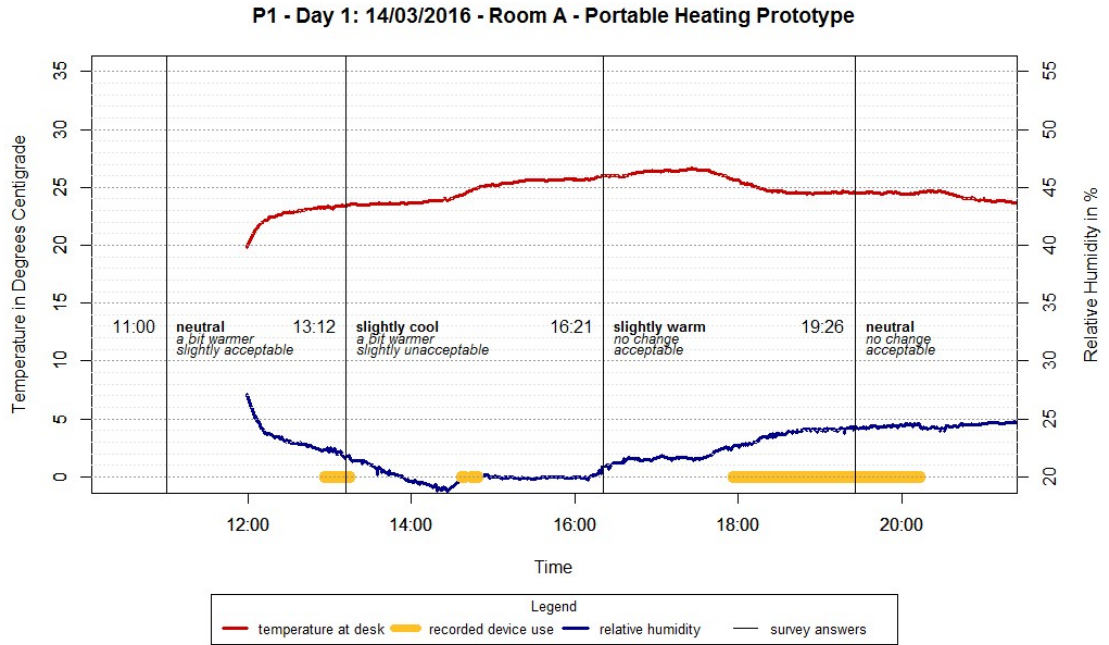
TC	ID	Conversation
01:18	A11	Sure
01:18	I	the left or the right hand?
01:19	A11	Um... my left one. Because I use mouse, my, my, um, I mean. My left, uh, hand is fixed so I used it for my left hand.
01:31	I	Okay, okay. Thank you very much. And, um, then you had the wearable prototype.
01:38	A11	Uh-um.
01:38	I	This one. And, um, same question: how did you use it? Can you please explain.
01:44	A11	Uh... Yes. I used it on my body, on my chest. So, uh... yeah, mainly on my chest.
01:55		But the, there was a problem, like, uh, because I type, and I work with mouse. It wasn't staying on my chest. So, it was falling down all the time. That was the only problem.
02:07		But there was a very good thing about it that the texture of this fabric could, air could flow through. Uh, I wasn't sweating because that's my main problem with heating wearables.
02:20	I	Okay.
02:20	A11	So, I wasn't sweating, and it was a good texture of - I, I liked it! - a good texture of cold weather and the warm thing, this warm thing.
02:29		And the, uh, the elements were not getting too hot. It was reasonable, it was nice.
02:38	I	Okay. That sounds good.
02:40	A11	But the circuits were a little bit annoying, the circuits. Yeah.
02:43	I	Well, the sensing, the sensing circuit -
02:46	A11	Yeah, yeah, because, yeah.
02:48	I	Okay.
02:48	A11	If they could be integrated somewhere inside, I mean, I couldn't, there wouldn't be this a little bit sharpie things.
02:55	I	Uh-um.
02:55	A11	Otherwise it was nice. I prefer this one, the scarf.
02:58	I	Ah, okay. Okay. And, um... so when you had both available, which one did you use?
03:08	A11	Uh... The scarf.
03:10	I	Okay.
03:10	A11	The scarf. One day, uh, was too hot but the other day I used the scarf.
03:14	I	Okay. And, um, because I only gave you one battery, so you could only use one at the time. But, um, if you could have used both of them at the same time, would you have used them? Or?
03:31	A11	At the same time? Uh, well, depends on how cold the weather is but normally I wouldn't because, you know, you need to put them on.
03:44		If my chair has a place to put them there and I don't need to arrange them all the time, I would use it.
03:49		Otherwise because they'll fall down all the time or, you know. Yeah.
03:54	I	Okay. It's good. And, um, did you think about taking the prototypes with you when you were leaving your office?
04:05	A11	The scarf, yes! [A11 laughing] Yes. But I thought I wasn't supposed to take it home [both laughing].
04:13	I	Okay... Okay, so you would use it at home basically.
04:18	A11	Yes, yes.
04:20	I	Okay.
04:20	A11	Uh, yeah, actually, I'd like to use it at home. Yeah.
04:23	I	Yeah, and around campus?
04:26	A11	Uh, on campus? You know where?
04:28	I	I don't know. Do you spend most of your time in the office -
04:32	A11	Yes, most of the time I am in the office but -
04:32	I	or do you also work in other places?

TC	ID	Conversation
04:34	A11	Uh... if I didn't have the problem with the battery and the battery connection on this stuff, I would, would've thought about taking it somewhere else.
04:45	I	Uh-um.
04:45	A11	But I, I can use it only in, with this shoe shank, I can only use it somewhere, uh, sitting somewhere.
04:51	I	Yeah, okay, I understand. Um, actually, you already kind of answered the next question because, um, in the questionnaire you mentioned that the wearable prototype, the scarf, limited your mobility at your desk and you -
05:08	A11	Both of them limited my mobility.
05:10	I	Okay. Yeah, that would have been my question. [I laughing] Next question.
05:13	A11	Cause this one is my lower back but not the lower, lower back. I needed it to be like somewhere in the middle -
05:19	I	Ah, okay.
05:19	A11	And whenever I was, um... sitting upright it was falling down, I needed again to adjust it.
05:26	I	Yeah.
05:26	A11	So that posed a problem.
05:27		But if it was attached to me, I mean, it has something to attach it to my, uh-uh, seat back, yeah, it would be much easier to use.
05:36	I	Okay, and, um, with the scarf the problem was that it -
05:41	A11	Falling down.
05:42	I	Okay.
05:43	A11	And, um, the kind of shank, the external connection things, battery and wire and... yeah.
05:49	I	Okay. Okay. Okay. Thank you! That was all.
05:53	A11	Was that all?
05:53	I	That's it already.
05:54	A11	Yeah, it was nice.

D.4 Environmental Data and Right Now Survey Plots

Participant A1

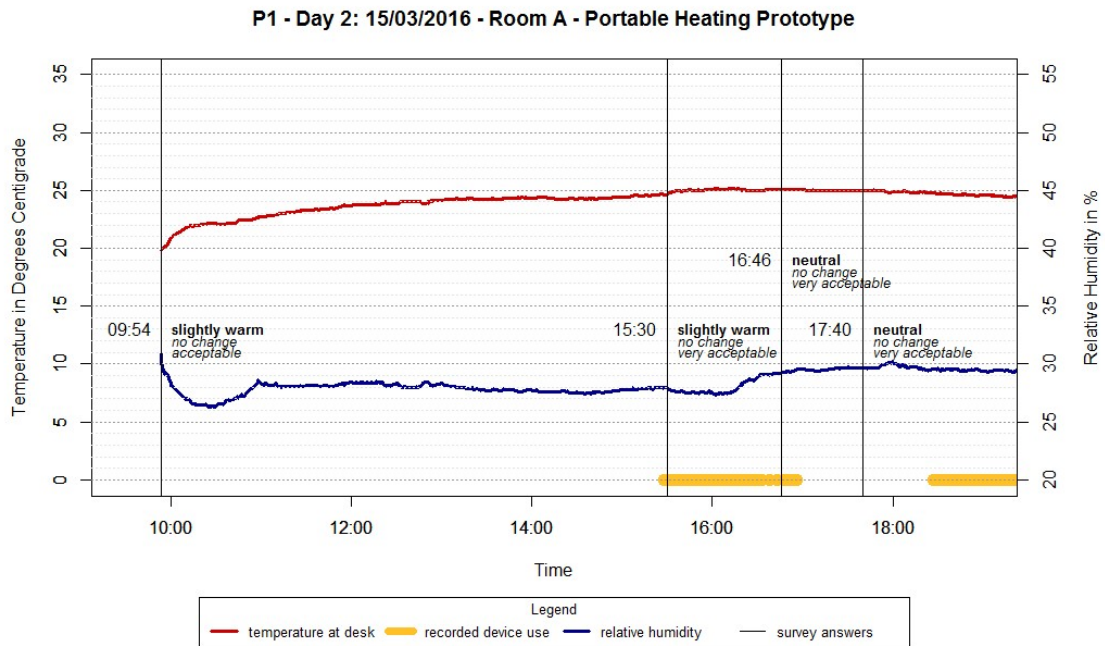
A1 – Day 1, Portable Heating Prototype, Room B



Outdoor Weather	clear/sunny
Clothing	short sleeved shirt/top, trousers/long skirt, and cardigan; long socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:00	Seated, active	Room heating on	Hot	
13:12	Seated, active	Room heating on, heating system does not provide enough heating	At room temperature	Prototype on (I felt cool)
16:21	Seated, active	Room heating on, blinds down	At room temperature	Prototype off (“I turned it off when left the office and when I came back it was warm enough”)
19:26	Seated, active	Room heating on, air-conditioning on	At room temperature	Prototype on (I felt cool)

A1 – Day 2, Portable Heating Prototype

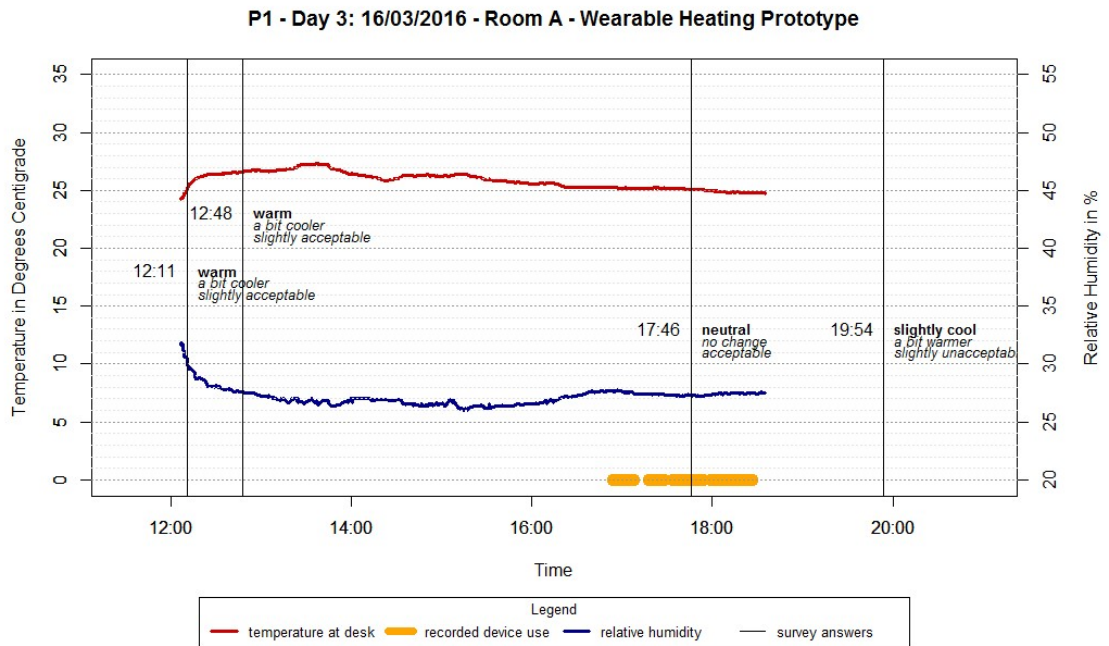


Outdoor Weather	Cloudy/grey
Clothing	short sleeved shirt/top, trousers/long skirt, and cardigan; long socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:54	Walking, outdoors	Room heating on; lights on		
15:30	Walking, outdoors	Room heating on; lights on	At room temperature	Prototype on (“I like the warm feeling at my back.”)
16:46	Seated, active	Room heating on; lights on	At room temperature	
17:40	Seated, active	Room heating on; lights on		Prototype off (“Was uncomfortable sitting with pillow in the back. I turned my heating pad on instead.”)

Comments	“I was out of office from 10am - 3pm.”
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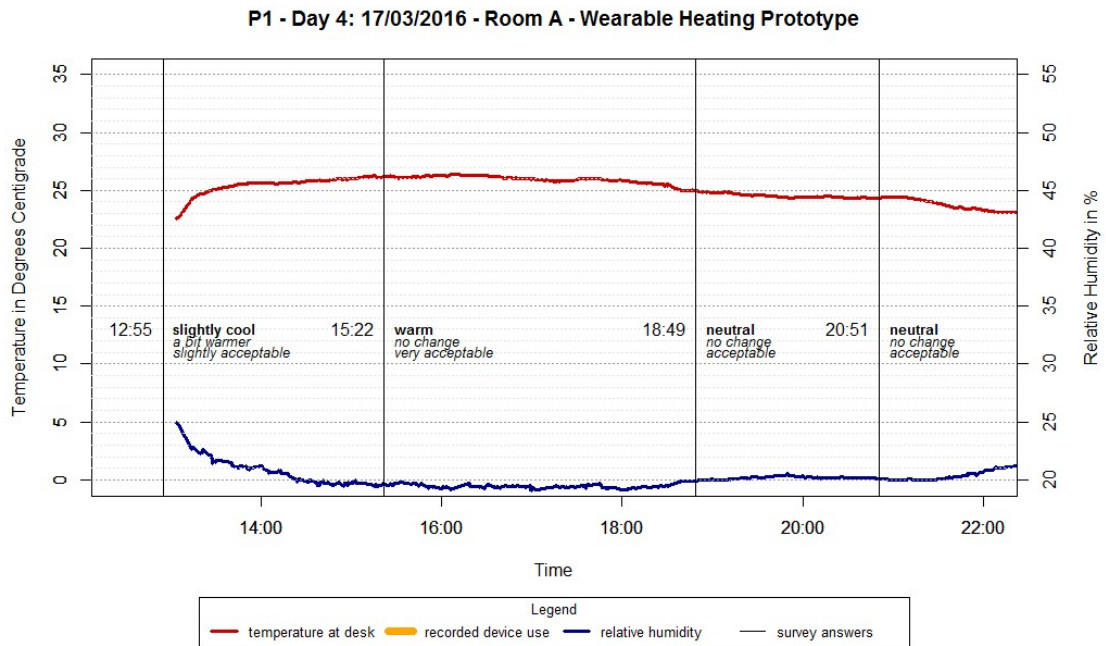
A1 – Day 3, Wearable Heating Prototype



Outdoor Weather	Partly cloudy with sunny spells
Clothing	short sleeved shirt/top, trousers/long skirt, and cardigan; long socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:11	Seated, active	Room heating on; lights on; room heater on; Heating system provides too much heating		
12:48	Seated, active	Room heating on; lights on; room heater on (“but turned down a bit”) Heating system provides too much heating		
17:46	Seated, active	Room heating on; lights on	At room temperature	Prototype on (“I wanted to try it out.”)
19:54	Seated, active	Room heating on; lights on; Drafts from windows/vents; heating system does not provide enough heating	At room temperature	Prototype off (“I put my office jacket on and did not feel like using the device any more.”)

A1 – Day 4, Wearable Heating Prototype

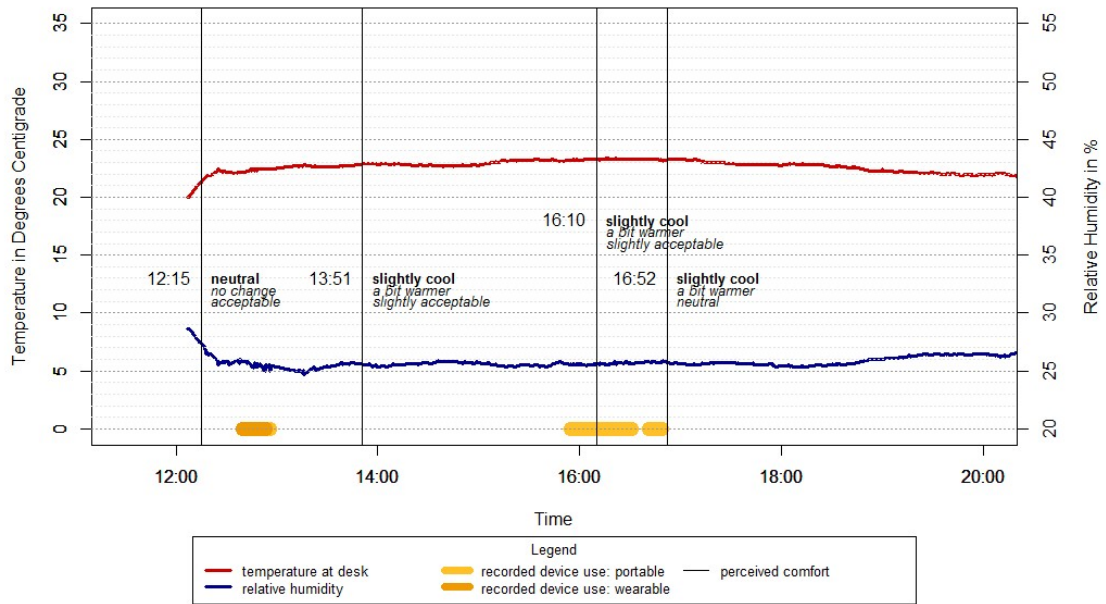


Outdoor Weather	Clear/sunny
Clothing	short sleeved shirt/top, trousers/long skirt, and short/long sleeved cardigan; long socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:55	Seated, "sitting in the sun and having lunch"	Room heating on; lights on;	At room temperature	
15:22	Seated, active	"I would assume that the heating is off because it is quite warm, but I did not check"; lights on;	Cold	
18:49	Seated, active	Room heating on; lights on	At room temperature	Item of clothing on; I felt cool;
20:51	Seated, active	Room heating on; lights on;	At room temperature	

A1 – Day 5, Wearable and Portable Heating Prototypes

P1 - Day 5: 18/03/2016 - Room A - Both Prototypes

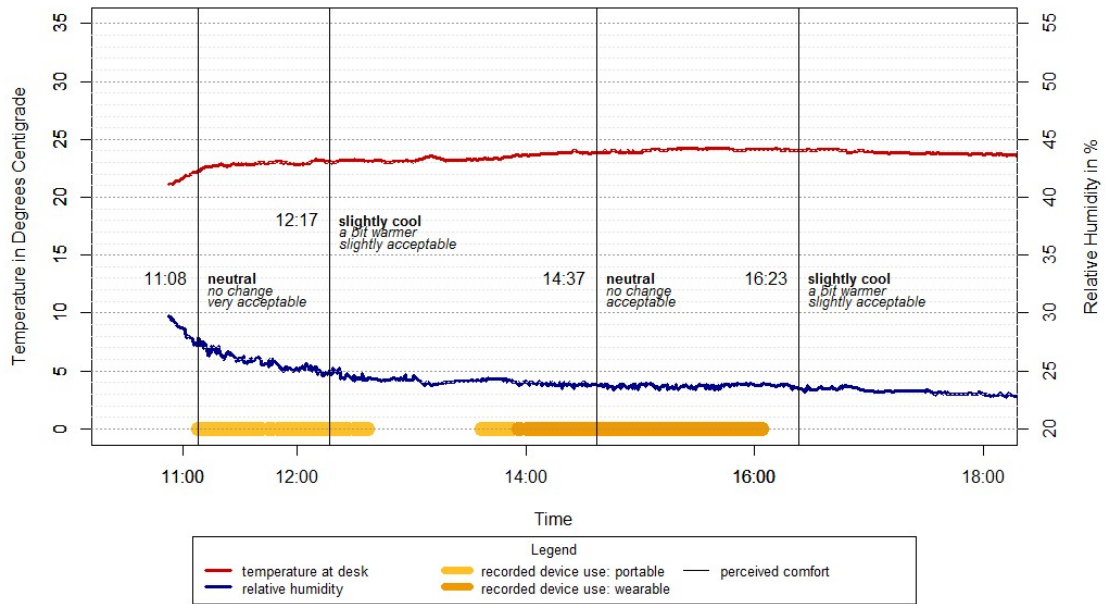


Outdoor Weather	Cloudy/grey
Clothing	short sleeved shirt/top, trousers/long skirt, and cardigan; long socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:15	Seated, active	Room heating on; lights on;		
13:51	Seated, active	Room heating on; lights on; Heating system provides not enough heating		
16:10	Seated, active	Room heating on; lights on; Heating system provides not enough heating		Prototype on; I felt cool;
16:52	Seated, active	Room heating on; lights on; Heating system provides not enough heating		Prototype off ("Ran out of battery")

A1 – Day 6, Wearable and Portable Heating Prototypes

P1 - Day 6: 21/03/2016 - Room A - Both Prototypes



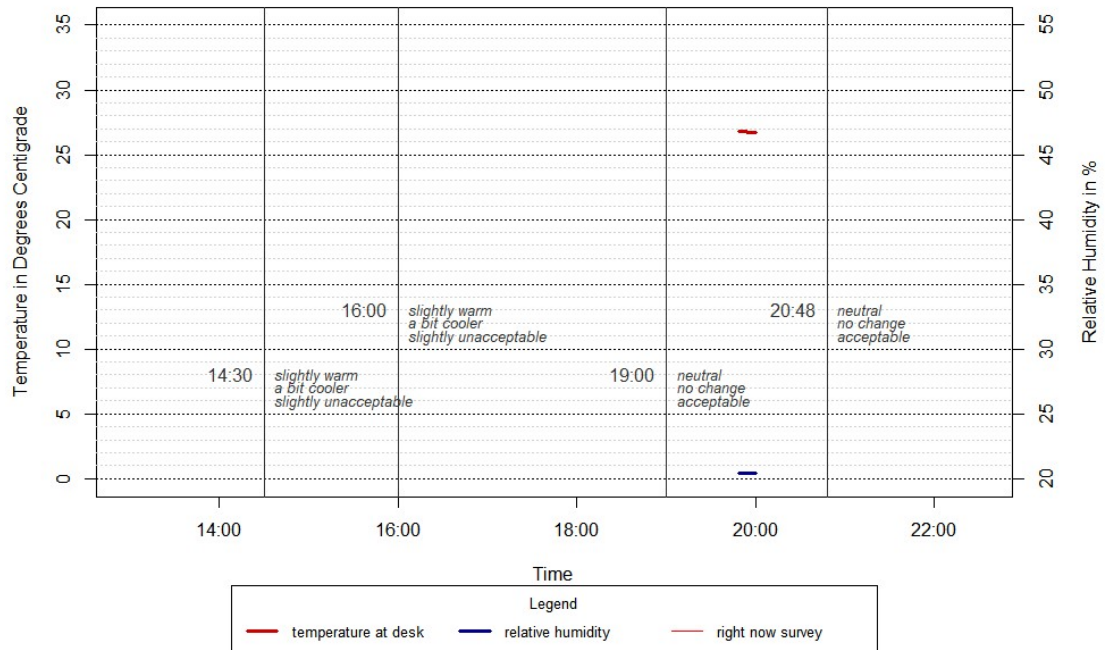
Outdoor Weather	Partly cloudy to cloudy/grey
Clothing	short sleeved shirt/top, trousers/long skirt, and cardigan; long socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:08	Seated, active	Room heating on; lights on;	Cold	Prototype on; "To warm my stomach a bit"
12:17	Seated, active	Room heating on; lights on;	Cold	
14:37	Seated, active	Room heating on; lights on;	At room temperature	Prototype on; "I liked to try out the shawl again and put it on my lap"
16:23	Seated, active	Room heating on; lights on;	At room temperature	Prototype off ("out of battery")

Participant A2

A2 – Day 1, Wearable Heating Prototype

P2 – Day 1: 23/03/2016 - Room D - Wearable Heating Prototype



Outdoor Weather	Partly cloudy to cloudy/grey
Description	short sleeved shirt/top, Shorts/short skirt, tights/leggings, and cardigan; short socks and shoes;

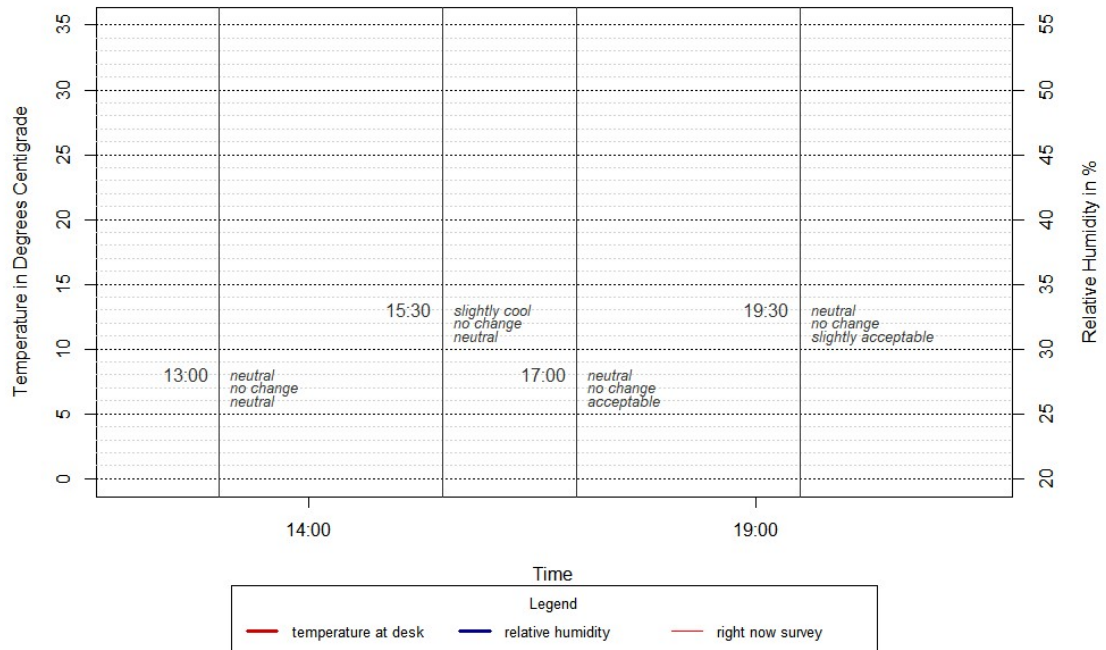
Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
14:30	Walking, outdoors; Seated, passive	Windows open; blinds down; room heating on; lights on; Air movement too low; heating system provides too much heating;	At room temperature	Prototype off; I felt warm
16:00	Seated, active	Windows open; blinds down; room heating on; lights on; Air movement too low; heating system provides too much heating;	At room temperature; hot	Prototype off
19:00	Seated, active	Windows open; blinds down; room heating on; lights on;	At room temperature	Prototype off

20:48	Seated, active	Windows open; blinds down; room heating on; lights on;	At room temperature	Prototype on; I felt cold;
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Comments	“did not turn it on yet as feel already warm.”
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A2 – Day 2, Wearable Heating Prototype

P2 – Day 2: 24/03/2016 - Room D - Wearable Heating Prototype



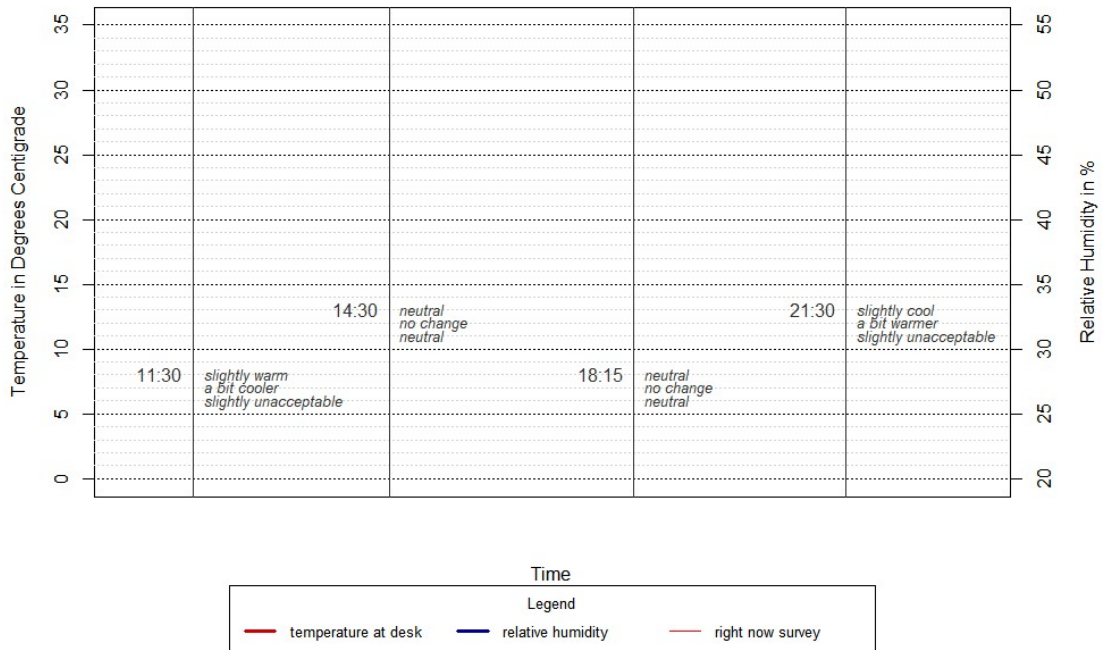
Outdoor Weather	cloudy/grey to drizzly
Clothing	short sleeved shirt/top, Shorts/short skirt, tights/leggings, and cardigan; short socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
13:00	Walking, outdoors;	Windows open; blinds down;	At room temperature	
15:30	Seated, active	Windows open; blinds down;	At room temperature	
17:00	Seated, active	Windows open; blinds down;	At room temperature	
19:30	Seated, active; Walking, indoors;	blinds down;	At room temperature	Prototype on; I felt cold;

Comments	“I like being able to control my individual thermal comfort as usually the office is either too warm or too cold...”
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A2 – Day 3, Portable Heating Prototype

P2 – Day 3: 30/03/2016 - Room D - Portable Heating Prototype



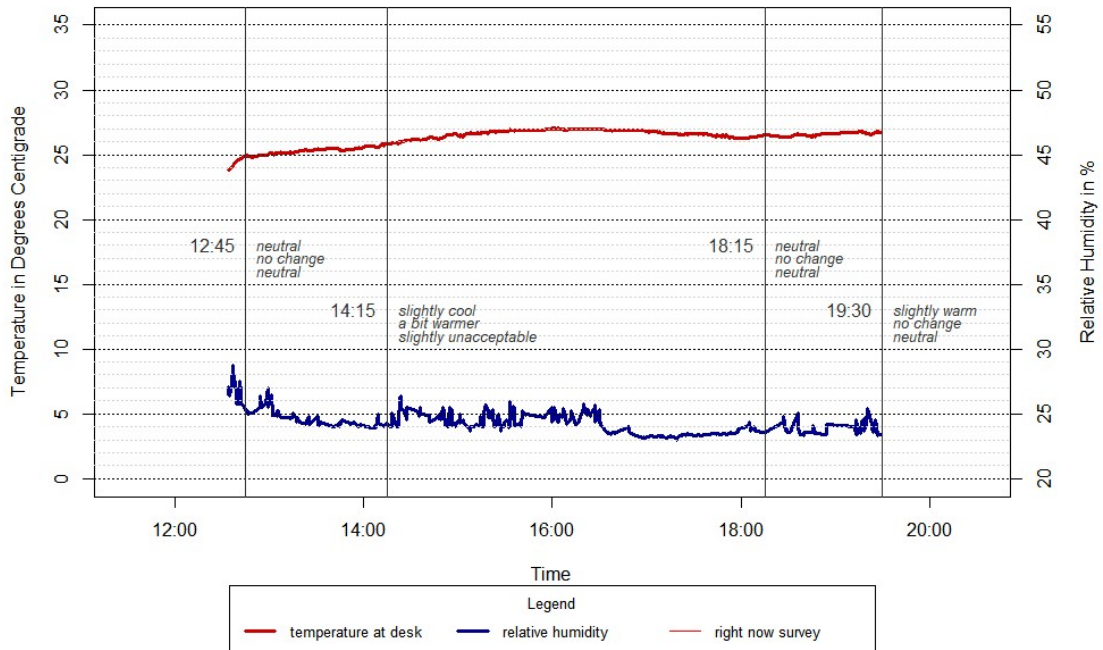
Outdoor Weather	Clear/sunny, partly cloudy
Clothing	long sleeved shirt/top, Shorts/short skirt, tights/leggings, and cardigan; short socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:30	Walking, outdoors; Seated, passive;	Windows open; blinds down; lights on; Air movement too low;	At room temperature	
14:30	Seated, active	Windows open; blinds down; lights on;	At room temperature	
18:15	Seated, active	Windows open; blinds down; lights on;	At room temperature	
21:30	Seated, active;	blinds down; lights on; Drafts from windows/vents;	At room temperature	Prototype on; Windows closed; I felt cold;

Comments	“I like being able to control my individual thermal comfort as usually the office is either too warm or too cold...”
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A2 – Day 4, Portable Heating Prototype

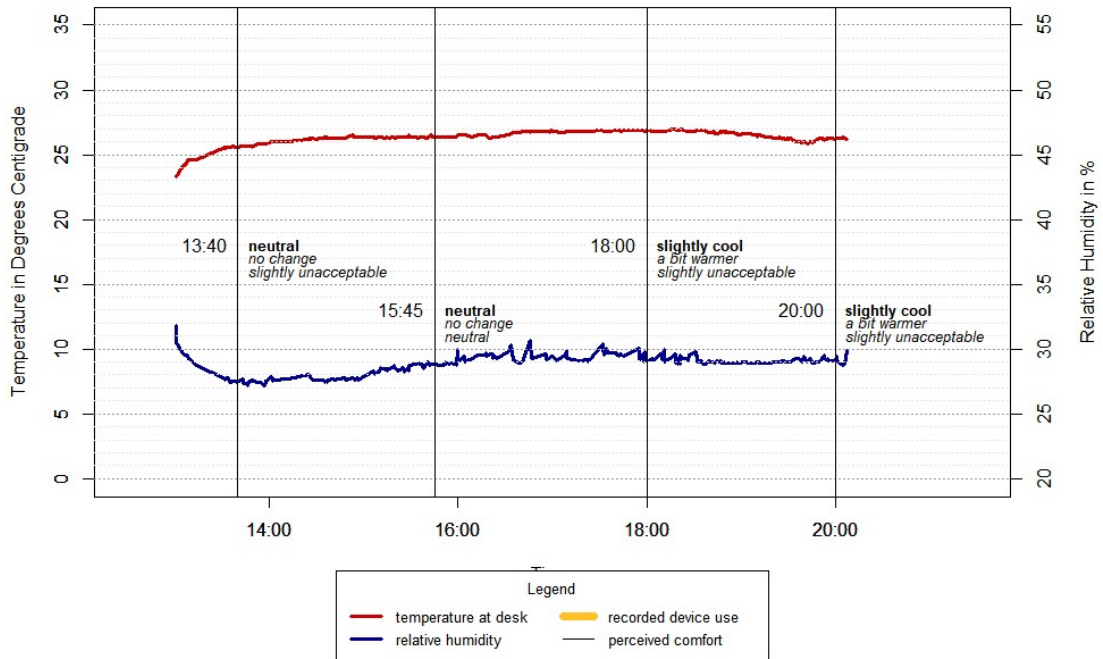
P2 – Day 4: 18/04/2016 - Room D - Portable Heating Prototype



Outdoor Weather	Partly cloudy, cloudy/grey
Clothing	short sleeved shirt/top, Shorts/short skirt, tights/leggings, and cardigan; short socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:45	Walking, outdoors; Seated, passive;	Blinds down	At room temperature	
14:15	Seated, active; Walking, indoors;	Blinds down; Air movement too low; "Air is stuffy"	At room temperature	Prototype on; I felt cold;
18:15	Seated, passive; Walking, outdoors;	Blinds down		
19:30	Seated, active;	Blinds down	At room temperature	Prototype off; "Put prototype to charge"

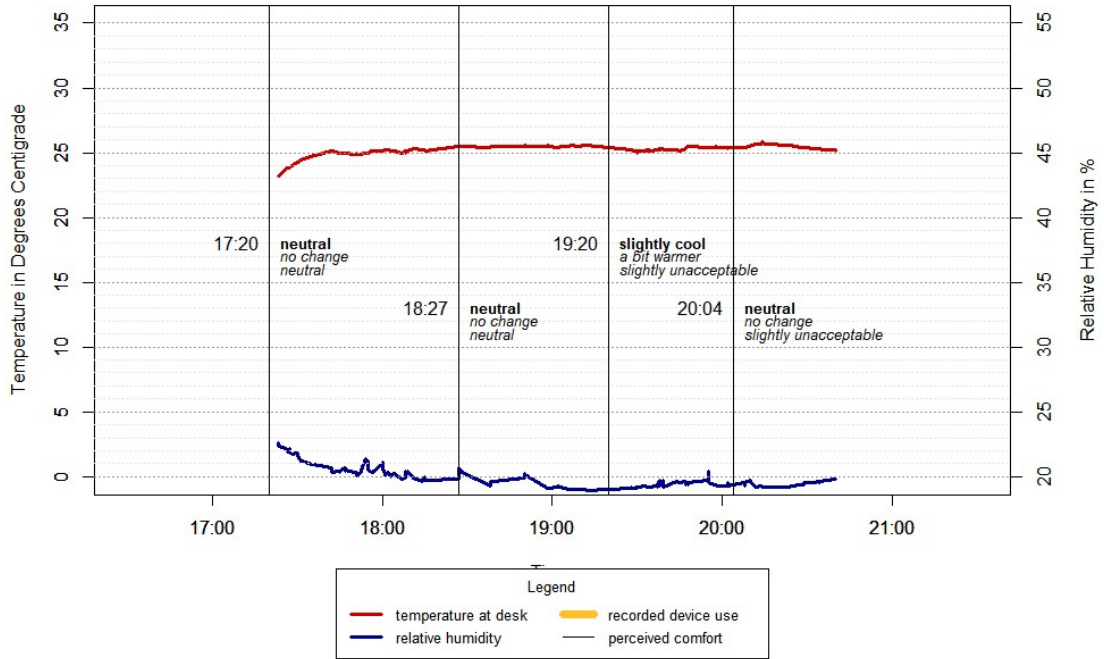
P2 – Day 5: 22/04/2016 - Room D - Both Prototypes



Outdoor Weather	Cloudy/grey, drizzly/rainy
Description	short sleeved shirt/top, Shorts/short skirt, tights/leggings, and cardigan; short socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
13:40	Walking, indoors; Seated, active;	Blinds down; lights on; Air movement too low; drafts from windows/vents	At room temperature	Prototype on (Blanket); windows closed; I felt cold;
15:45	Standing, passive; Walking, indoors;	Blinds down; lights on;		Prototype battery charging
18:00	Seated, active;	Blinds down; lights on; drafts from windows/vents	At room temperature	Prototype on (Blanket); I felt cool;
20:00	Standing, passive; “chatting”	Blinds down; lights on; drafts from windows/vents		

P2 – Day 6: 23/04/2016 - Room D - Both Prototypes

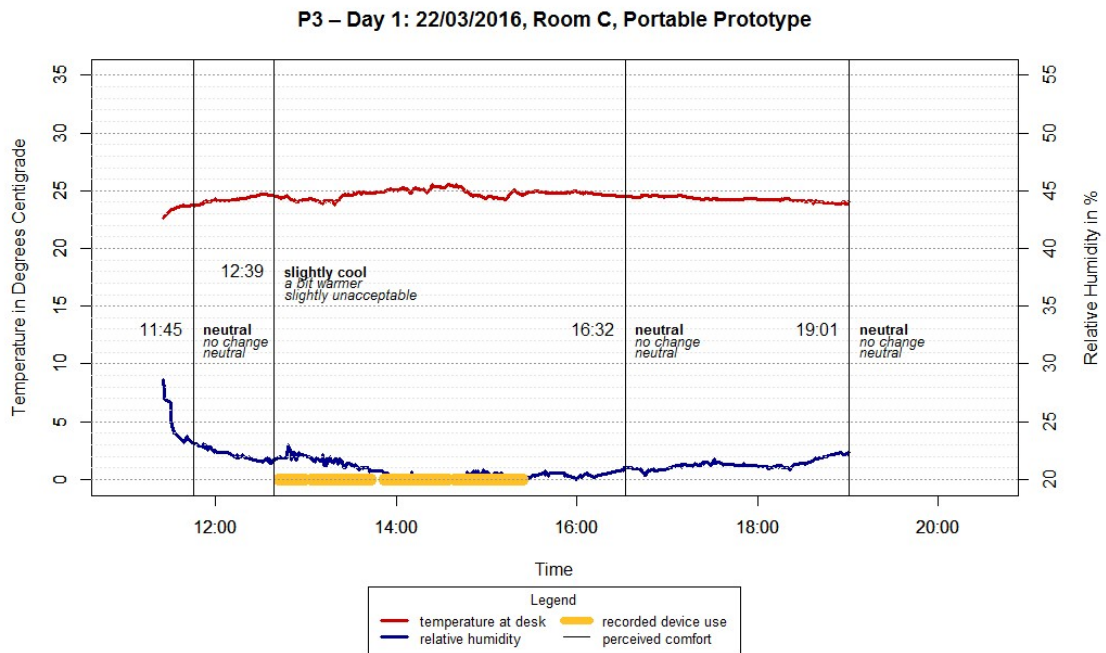


Outdoor Weather	Clear/sunny to partly cloudy
Description	short sleeved shirt/top, Shorts/short skirt, tights/leggings, and cardigan; short socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
17:20	Walking, outdoors; Standing, passive (chatting);	Blinds down; lights on;		
18:27	Seated, active;	Blinds down; lights on;	At room temperature	Prototype on (Blanket); I felt cold;
19:20	Seated, active;	Blinds down; lights on; drafts from windows/vents	At room temperature	Prototype on (Pillow); I felt cool;
20:04	Seated, active;	Blinds down; lights on; drafts from windows/vents		

Participant A3

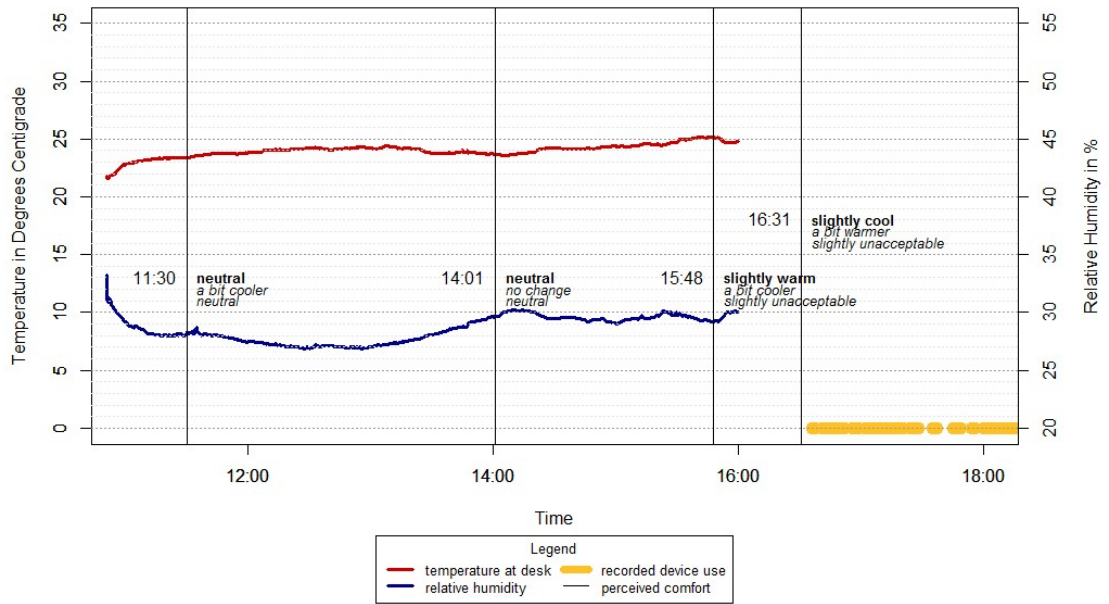
A3 – Day 1, Portable Heating Prototype, Room C, 22/03/2016



Outdoor Weather	Clear/sunny to partly cloudy
Description	long sleeved shirt/top, Shorts/short skirt, tights/leggings, and cardigan; short socks and shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:45	Seated, active	room heating on; lights on;	hot	
12:39	Seated, passive	room heating on; lights on;	hot	Prototype on; I felt cool Window open: fresh air
16:32	Seated, passive			
19:01	Seated, passive			

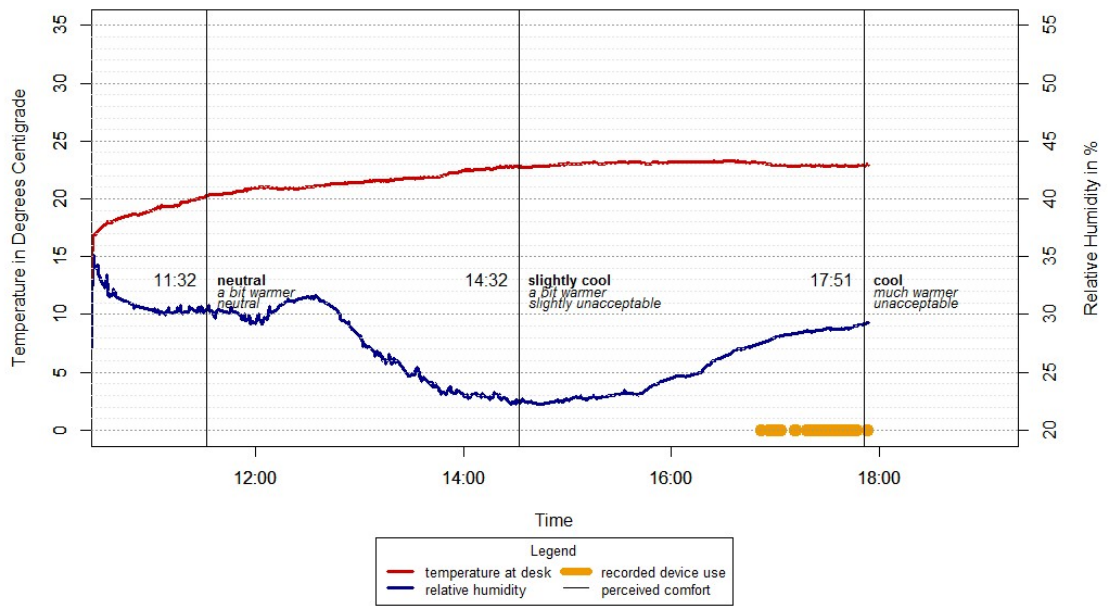
P3 – Day 2: 24/03/2016, Room C, Portable Prototype



Outdoor Weather	Clear/sunny to partly cloudy
Clothing	long sleeved shirt/top, Shorts/short skirt, tights/leggings, and cardigan; boots;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:30	Seated, passive	room heating on; lights on;	hot	
14:01	Seated, active	room heating on; lights on;	hot	Window open: fresh air
15:48	Seated, active	room heating on; lights on; heating system provides too much heating;		Window open: I felt warm Clothing: take off my jacket
16:31	Seated, active	room heating on; lights on;		Prototype on; I felt cool

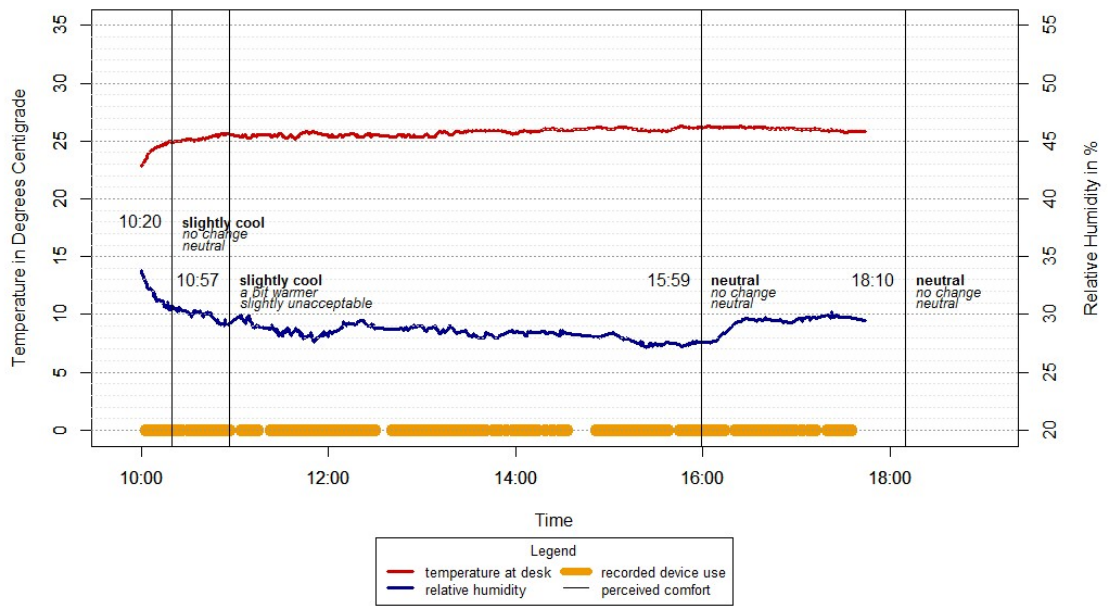
P3 – Day 3: 29/03/2016, Room C, Wearable Prototype



Outdoor Weather	Clear/sunny to partly cloudy to cloudy/grey
Clothing	trousers/long skirt, jumper/cardigan, jacket; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:32	Seated, active	lights on; heating system provides not enough heating;		
14:32	Standing, passive	lights on; heating system provides not enough heating;	At room temperature	Item of clothing on: I felt cool
19:51	Walking, indoors	lights on; heating system provides not enough heating;	At room temperature	Prototype on: I felt cold

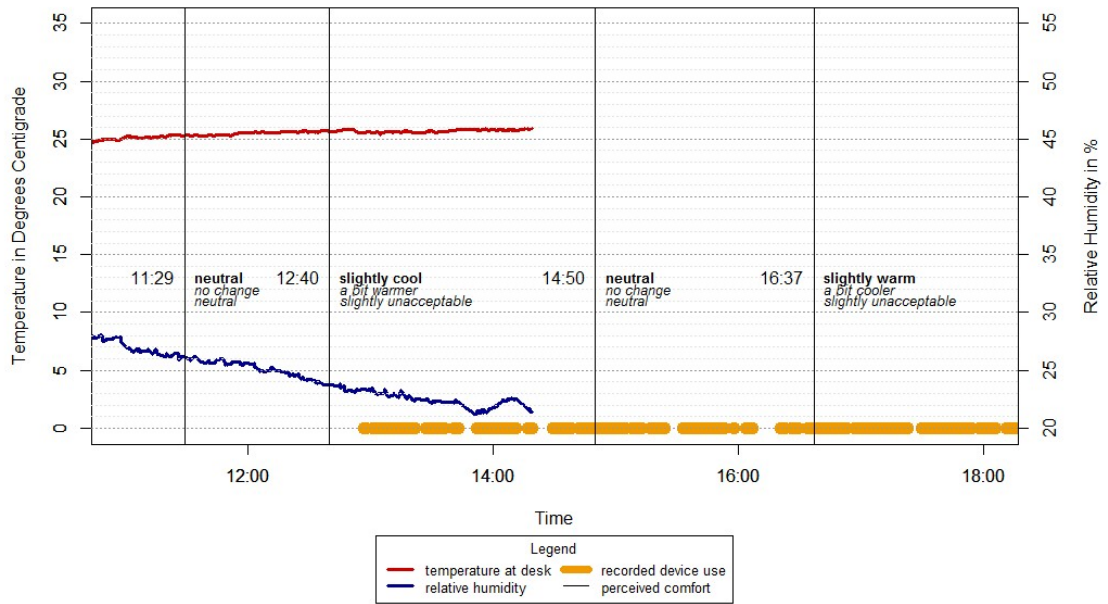
P3 – Day 4: 04/04/2016, Room C, Wearable Prototype



Outdoor Weather	Clear/sunny to partly cloudy
Clothing	trousers/long skirt, jumper/cardigan; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:20	Other (cycling to office)	window(s) open room heating on; lights on;	At room temperature	
10:57	Seated, active	window(s) open room heating on; lights on; heating system provides not enough heating	At room temperature	Prototype on: I felt cool
15:59	Seated, active	window(s) open room heating on; lights on; personal device provides too much heating;	At room temperature	Prototype off: I felt warm
18:10	Seated, active	window(s) open room heating on; lights on;	At room temperature	

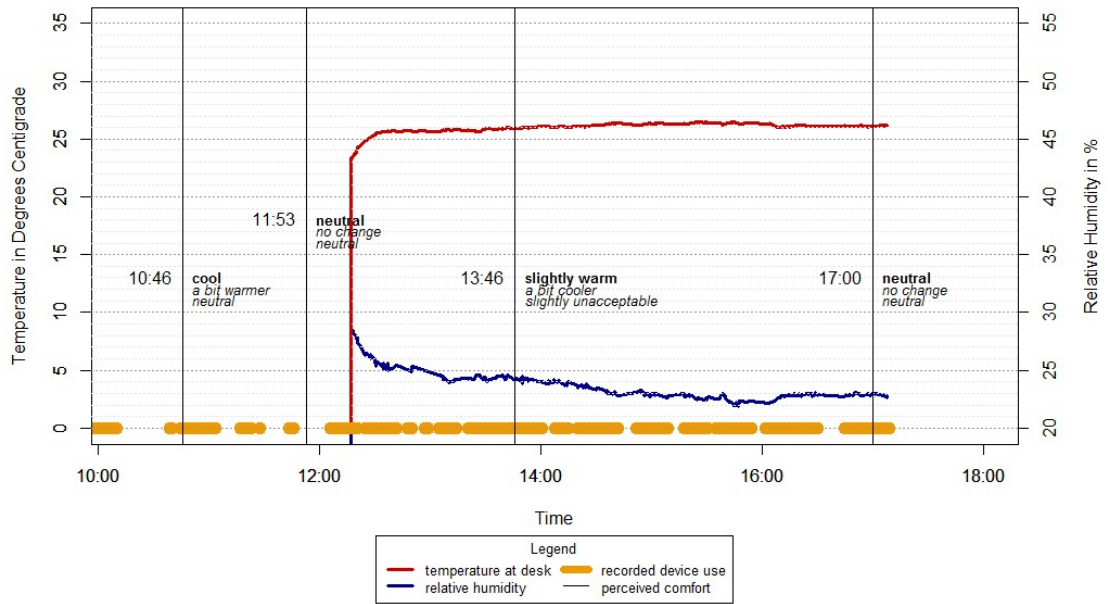
P3 – Day 5: 05/04/2016, Room C, Both Prototypes



Outdoor Weather	Clear/sunny
Clothing	trousers/long skirt, jumper/cardigan; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:29	Walking, outdoors; Seated, active;	room heating on; lights on;		
12:40	Seated, active	room heating on; lights on;	At room temperature	Prototype on: I felt cool
14:50	Seated, active	room heating on; lights on;	At room temperature	Prototype on: I felt cool
16:37	Seated, active	room heating on; lights on;		Prototype off: I felt warm

P3 – Day 6: 08/04/2016, Room C, Both Prototypes



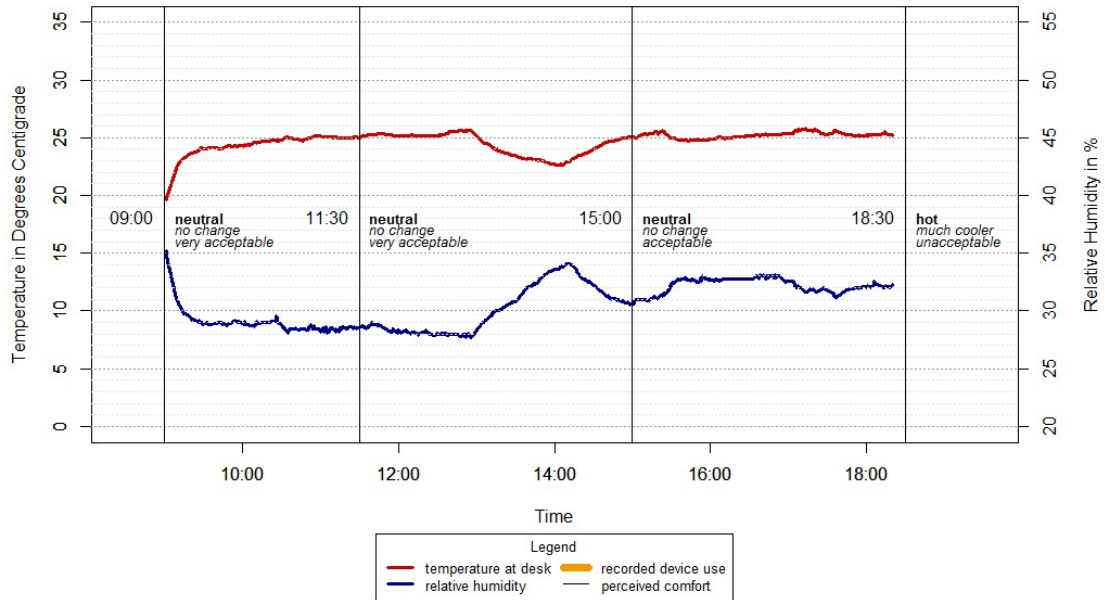
Outdoor Weather	Clear/sunny to partly cloudy
Clothing	Long sleeved shirt/top, trousers/long skirt, jumper/cardigan; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:46	Other (coming from outside in bike)	room heating on; lights on;		Took coat off: I felt cool; Prototype on: I felt cold;
11:53	Seated, active	room heating on; lights on;		Prototype on: I felt cold
13:46	Seated, active	room heating on; lights on; Personal device provides too much heating	hot	Prototype off
17:00	Seated, active	room heating on; lights on;		

Participant A4

A4 – Day 1, Wearable Heating Prototype, Room C, 24/03/2016

P4 – Day 1: 24/03/2016, Room C, Wearable Prototypes

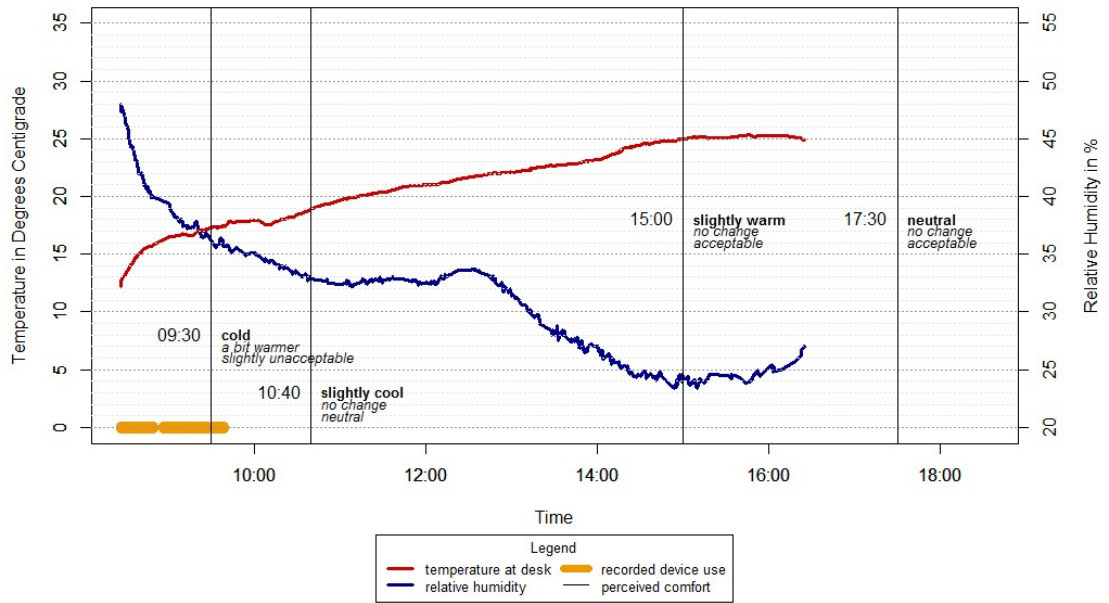


Outdoor Weather	partly cloudy
Description	jumper/cardigan; boots;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:00	Seated, active	Windows open; room heating on; lights on;	At room temperature;	Wearing scarf
11:30	Walking, outdoors	Windows open; room heating on; lights on;		Item of clothing off: "I'm feeling neither cold nor warm. There's no necessary to wear the scarf";
15:00	Seated, passive	room heating on; lights on; hot surrounding surfaces;		Heating down: I felt warm; window open
18:30	Seated, active	room heating on; lights on; air movement too low; hot surrounding surfaces; heating system provides too much heating;		Heating down: I felt hot;

A4 – Day 2, Wearable Heating Prototype, Room C, 29/03/2016

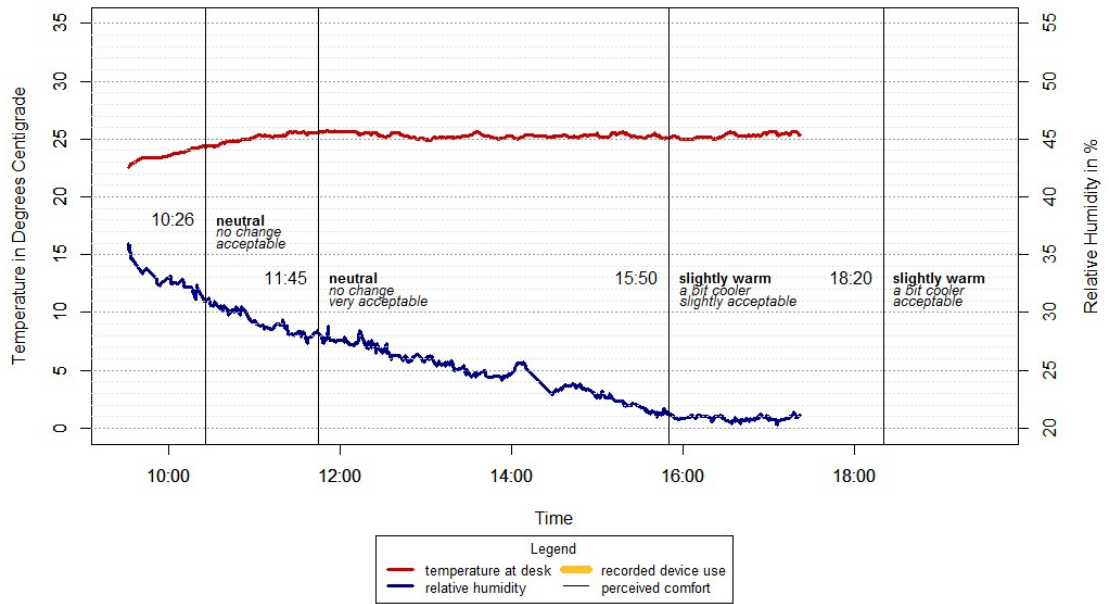
P4 – Day 2: 29/03/2016, Room C, Wearable Prototypes



Outdoor Weather	Clear/sunny to cloudy/grey
Clothing	short skirt, jumper/cardigan, long socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:30	Seated, active	Windows open; room heating on; lights on; Cold surrounding surfaces; Heating system provides not enough heating;	At room temperature;	Prototype on: "I felt cold"
10:40	Seated, active	room heating on; lights on; heater on; Heating system provides not enough heating;	At room temperature;	Prototype on: "I felt cold"
15:00	Standing, active	room heating on; lights on; heater on;	At room temperature;	
17:30	Seated, passive		Cold;	

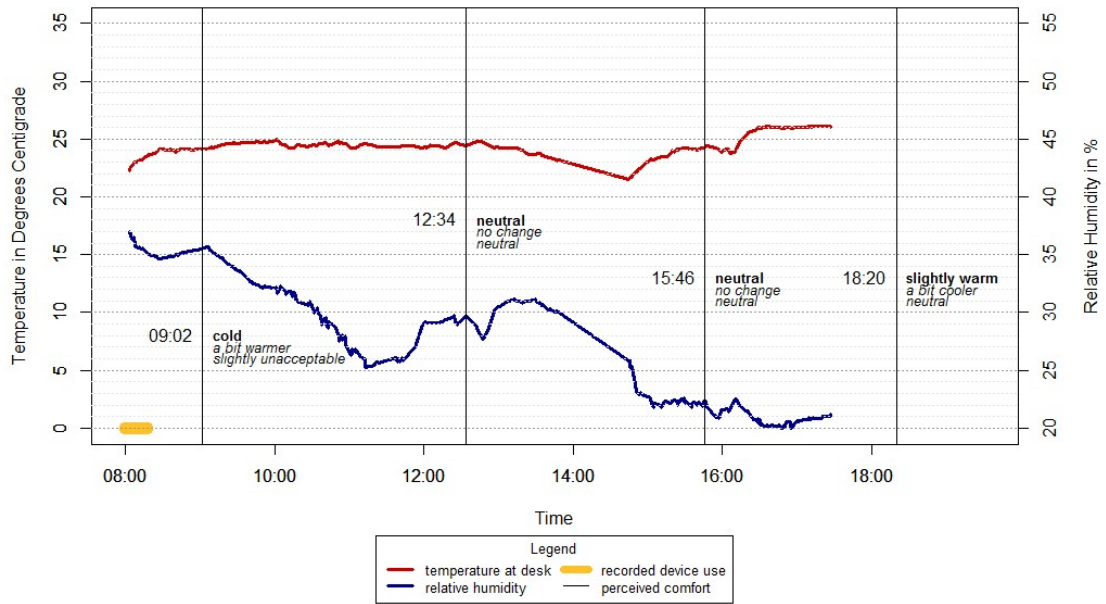
P4 – Day 3: 05/04/2016, Room C, Portable Prototypes



Outdoor Weather	Clear/sunny
Clothing	short sleeved shirt/top, jumper/cardigan, long socks; boots;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:26	Walking, outdoors;	Windows open; Blinds/curtains down; lights on;		
11:45	Seated, active	Windows open; Blinds/curtains down; lights on;		
15:50	Seated, passive	Windows open; Blinds/curtains down; lights on; Air movement too low (even with the windows open it's still very sultry)		
18:20	Seated, active	Windows open; Blinds/curtains down; lights on;	At room temperature;	

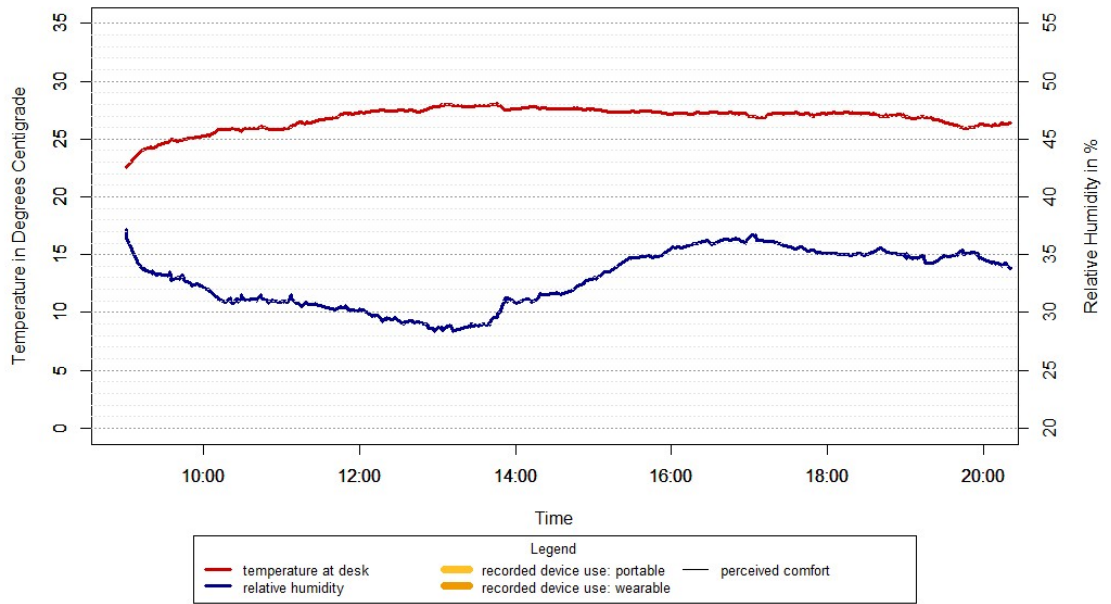
P4 – Day 4: 06/04/2016, Room C, Portable Prototypes



Outdoor Weather	Cloudy/grey to clear/sunny
Clothing	Long sleeved shirt/top, long skirt, long socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:30	Seated, active	Blinds/curtains down; lights on;		Prototype on: "I felt cold"
10:40	Walking, outdoors;	Windows open; Blinds/curtains down; lights on;		
15:00	Walking, outdoors;	Windows open; Blinds/curtains down; lights on;	At room temperature;	
17:30	Seated, active;	Blinds/curtains down; lights on;	C At room temperature;	

P4 – Day 5: 11/04/2016, Room C, Both Prototypes

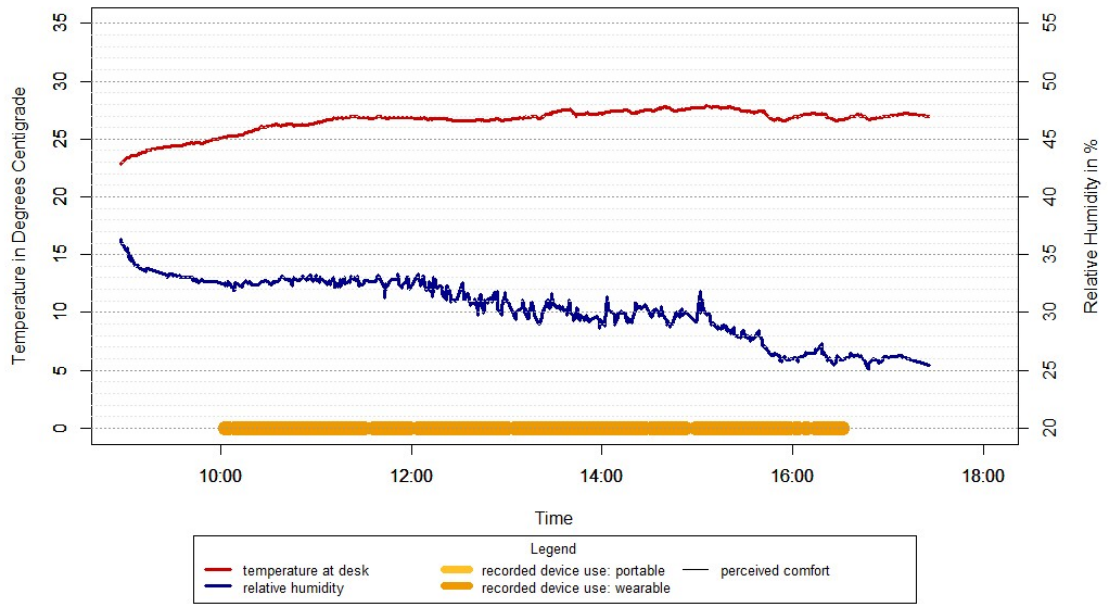


Outdoor Weather	
Clothing	

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation

Comments	
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P4 – Day 6: 12/04/2016, Room C, Both Prototypes



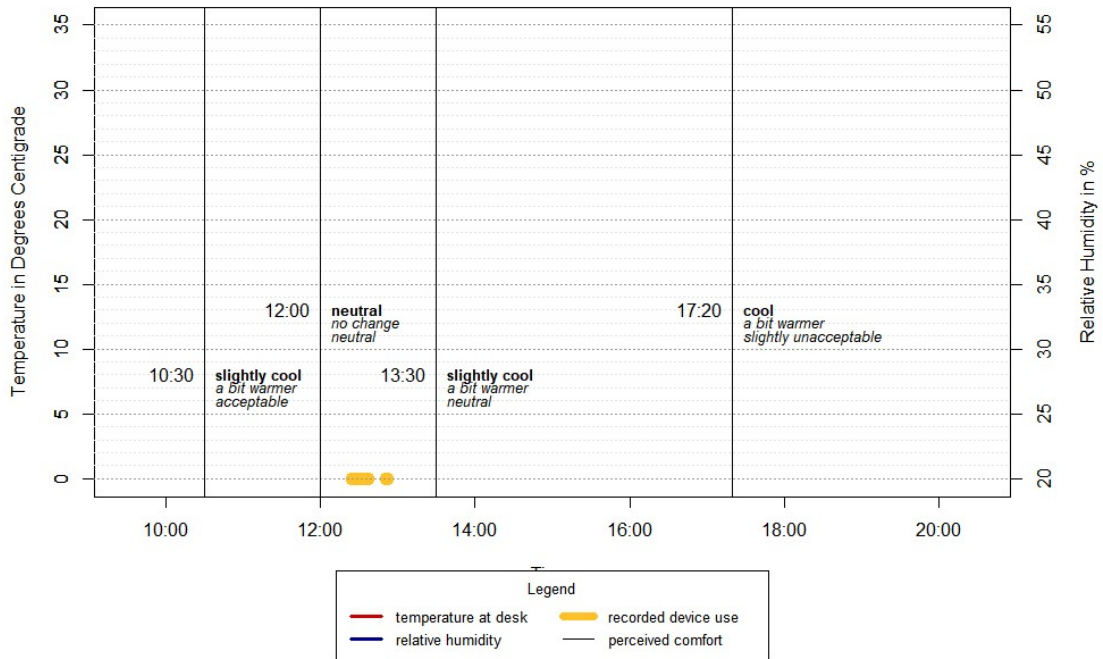
Outdoor Weather	
Clothing	

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation

Participant A5

A5 – Day 1, Portable Heating Prototype, Room D, 29/03/2016

P5 – Day 1: 29/03/2016 - Room D - Portable Heating Prototypes

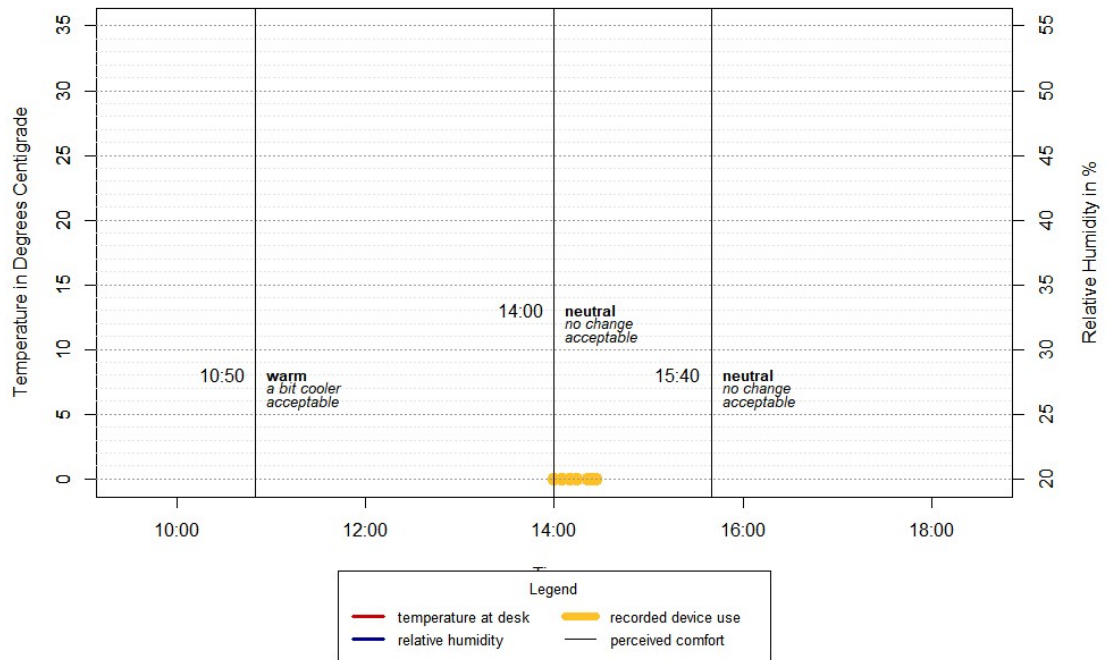


Outdoor Weather	Partly cloudy to cloudy/grey
Clothing	Short sleeved shirt/top, trousers, jumper/cardigan, 2x short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:30	Seated, passive;	Blinds/curtains down; Lights on;		
12:00	Standing, passive;	Windows open; Blinds/curtains down; Lights on;		
13:30	Seated, passive;	Windows open; Blinds/curtains down; Lights on; Drafts from windows/vents;	At room temperature;	
17:20	Standing, active;	Windows open; Blinds/curtains down; Lights on; Drafts from windows/vents;	At room temperature;	

A5 – Day 2, Portable Heating Prototype, Room D, 30/03/2016

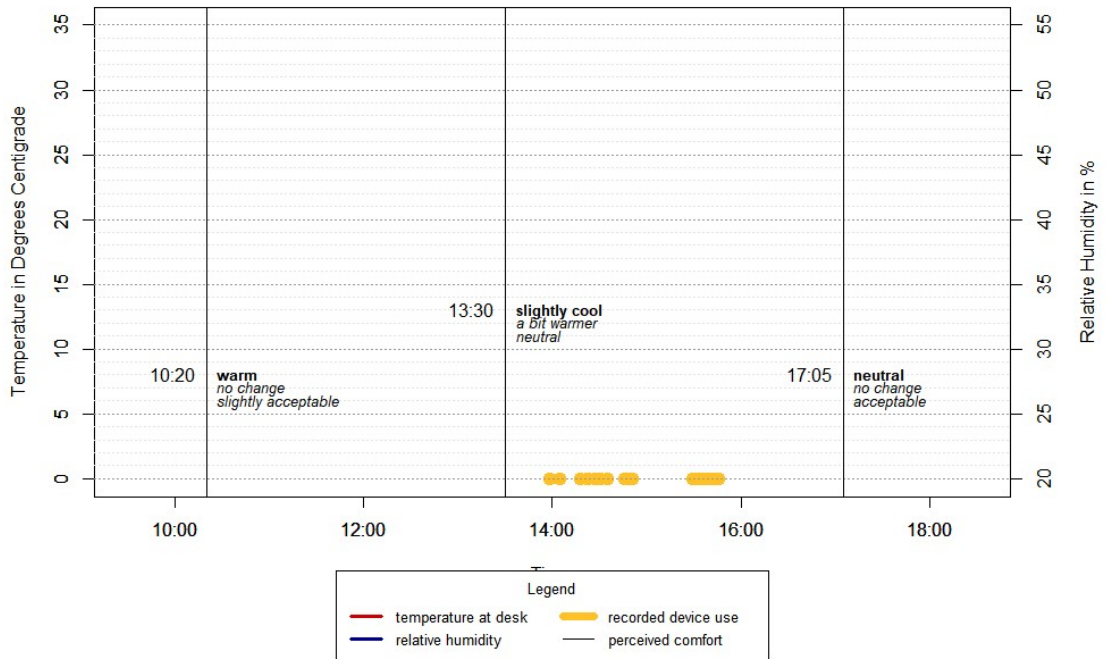
P5 – Day 2: 30/03/2016 - Room D - Portable Heating Prototypes



Outdoor Weather	Partly cloudy to cloudy/grey
Clothing	Short sleeved shirt/top, long sleeved shirt/top, trousers, 2x short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:50	Walking, outdoors	Windows open; Blinds/curtains down; Lights on;		
14:00	Seated, passive	Windows open; Blinds/curtains down; Lights on;		
15:40	Seated, passive	Windows open; Blinds/curtains down; Lights on;		

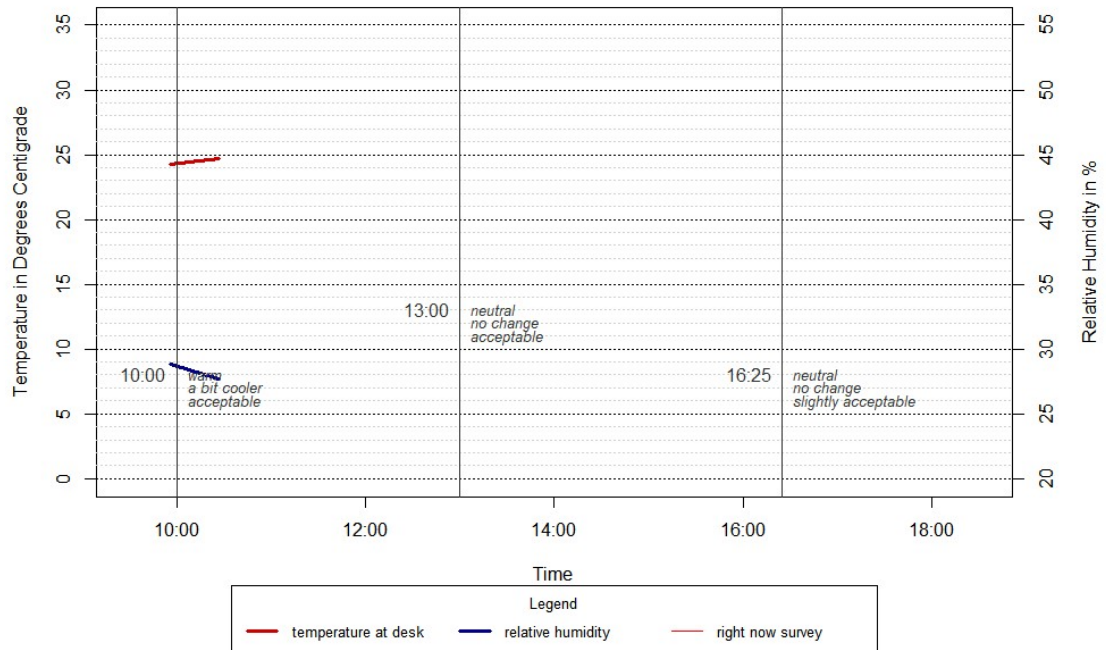
P5 – Day 3: 04/04/2016 - Room D - Wearable Heating Prototypes



Outdoor Weather	Partly cloudy to cloudy/grey to drizzly
Clothing	Short sleeved shirt/top, trousers, jumper/cardigan, 2x short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:20	Walking, outdoors;	Blinds/curtains down; Lights on;		
13:30	Seated, active;	Windows open; Blinds/curtains down; Lights on;	cold	Prototype on: "I felt cool";
17:05	Seated, active;	Blinds/curtains down; Lights on;		Prototype on: "I felt cool";

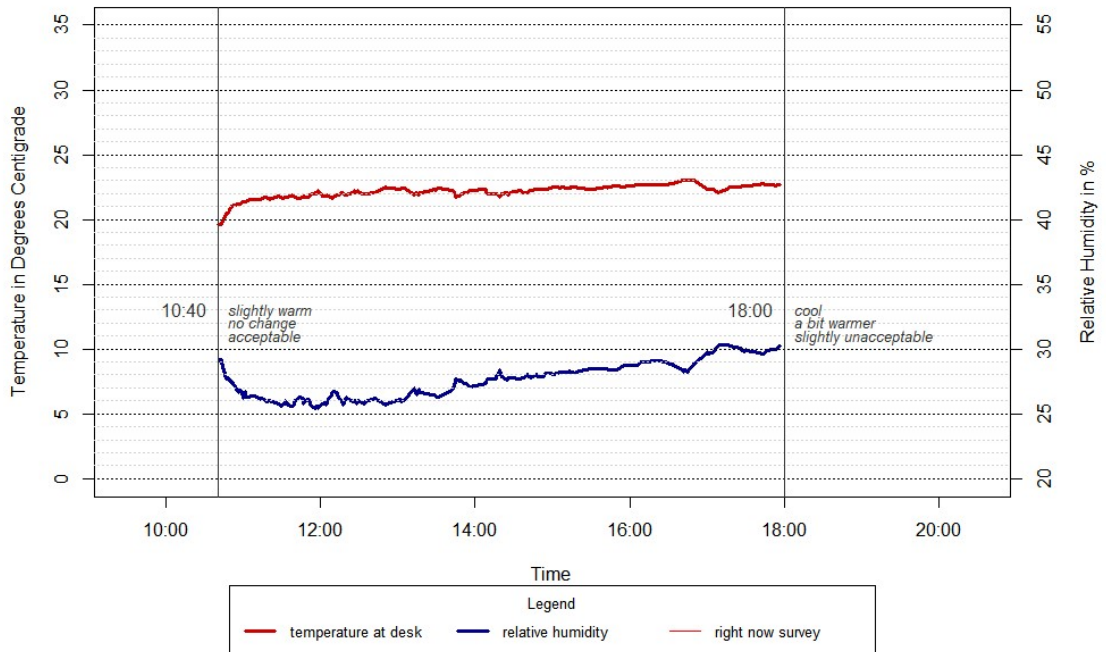
P5 – Day 4: 05/04/2016 - Room D - Wearable Heating Prototypes



Outdoor Weather	Partly cloudy
Clothing	Short sleeved shirt/top, long sleeved shirt/top, trousers, 2x short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:00	Walking, outdoors;	Blinds/curtains down; Lights on;		
13:00	Seated, active;	Blinds/curtains down; Lights on;	hot	Prototype on: "I felt cool"
16:25	Seated, active;	Blinds/curtains down; Lights on;	At room temperature	Prototype on: "I felt cool"

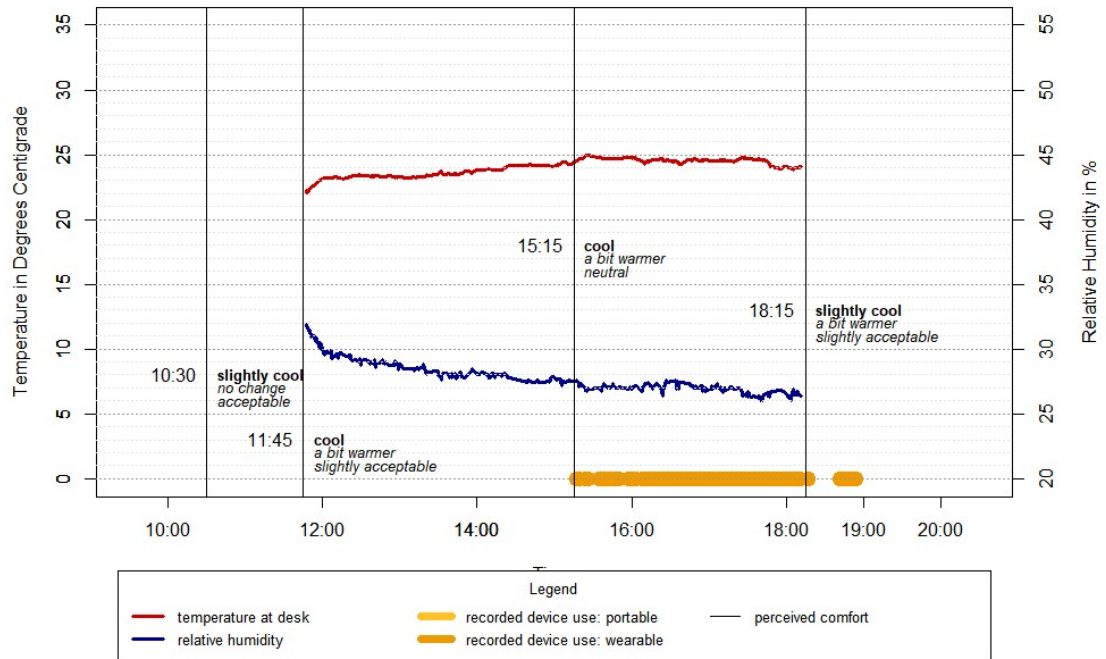
P5 – Day 5: 07/04/2016 - Room D - Both Prototypes



Outdoor Weather	Cloudy/grey and drizzly to rainy
Clothing	Short sleeved shirt/top, trousers, 2x short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:40	Walking, outdoors;	Blinds/curtains down; Lights on;		
18:00	Seated, active; Standing, active;	Blinds/curtains down; Lights on;	At room temperature	

P5 – Day 6: 08/04/2016 - Room D - Wearable Heating Prototypes



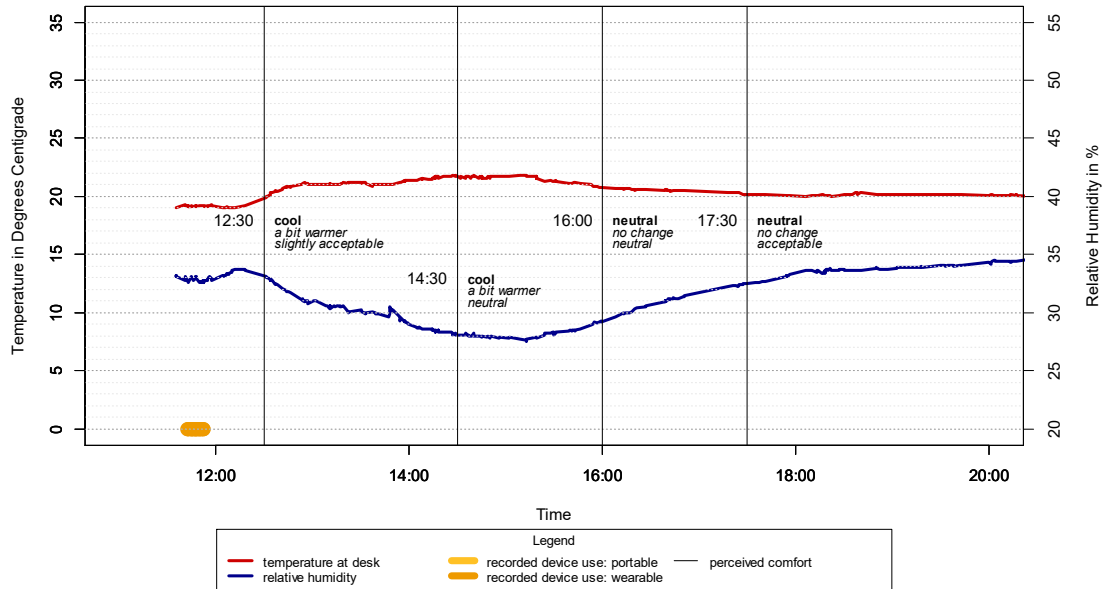
Outdoor Weather	Partly cloudy to cloudy/grey
Clothing	Short sleeved shirt/top, long sleeved shirt/top, trousers, 2x short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:30	Walking, outdoors;	Blinds/curtains down; Lights on;		Item of clothing off: "I felt hot" (long-sleeved shirt)
11:45	Seated, active;	Blinds/curtains down; Lights on;		Item of clothing on: "I felt cold" (long-sleeved shirt)
15:15	Seated, active; Walking, outdoors;	Blinds/curtains down; Lights on;		Prototype on: "I felt cold"
18:15	Seated, active;	Blinds/curtains down; Lights on;	At room temperature	Prototype on: "I felt cold"

Participant A6

A6 – Day 1, Wearable Heating Prototype, Room A, 29/03/2016

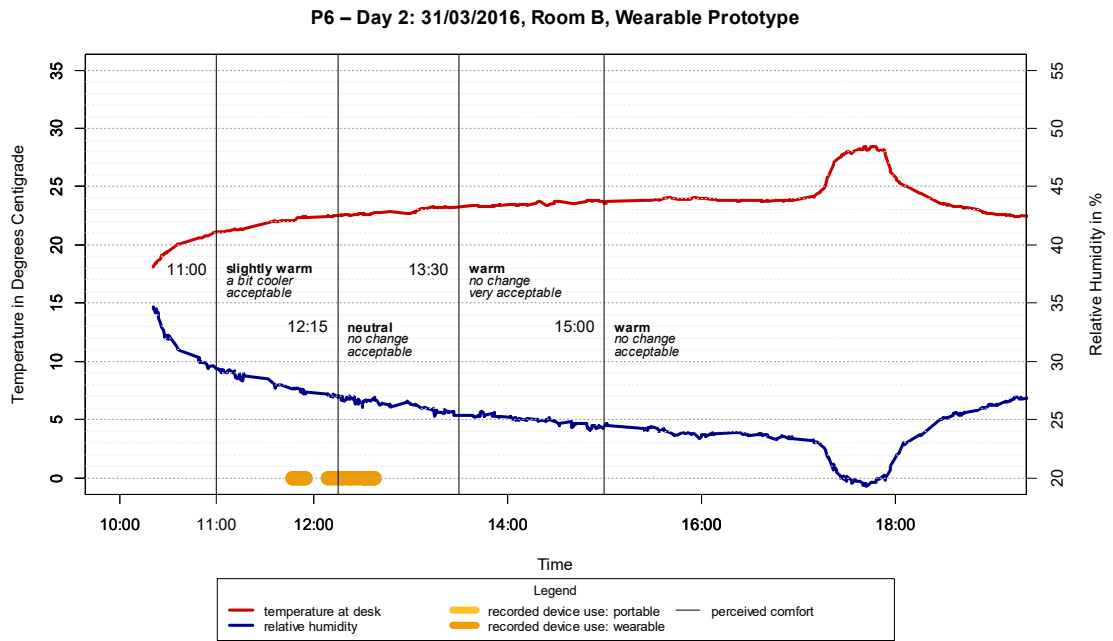
P6 – Day 1: 29/03/2016, Room B, Wearable Prototype



Outdoor Weather	Partly cloudy to cloudy grey to drizzly
Clothing	Short sleeved shirt/top, long sleeved shirt/top, vest, trousers/long skirt;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:30	Seated, passive;	Drafts from windows/vents;		
14:30	Walking, outdoors;	Drafts from windows/vents;	At room temperature;	
16:00	Seated, passive;	Room heating on; Drafts from windows/vents;	Cold;	Heating up: "I felt cold"
17:30	Seated, passive;	Drafts from windows/vents;		

Comments	"No one else was in the office today so could have temp how I liked it."
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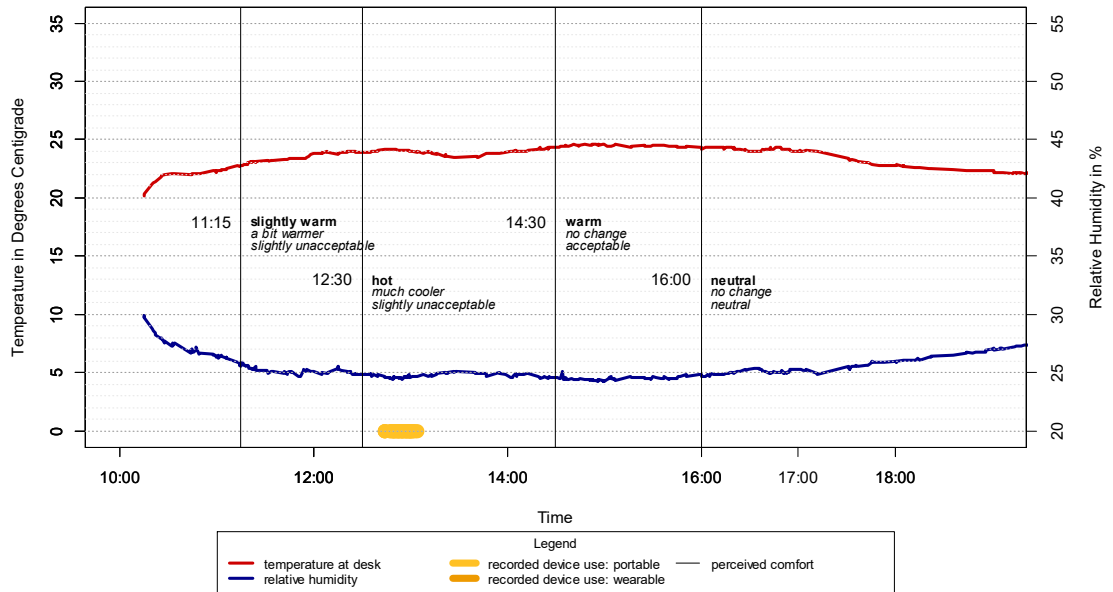


Outdoor Weather	Clear/sunny
Clothing	Trousers/long skirt, jumper/cardigan, long socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:00	Walking, outdoors;		At room temperature;	
12:15	Walking, indoors;		At room temperature;	
13:30	Seated, active;		cold	
15:00	Seated, active;			

Comments	“11 am - only one in office - all day”
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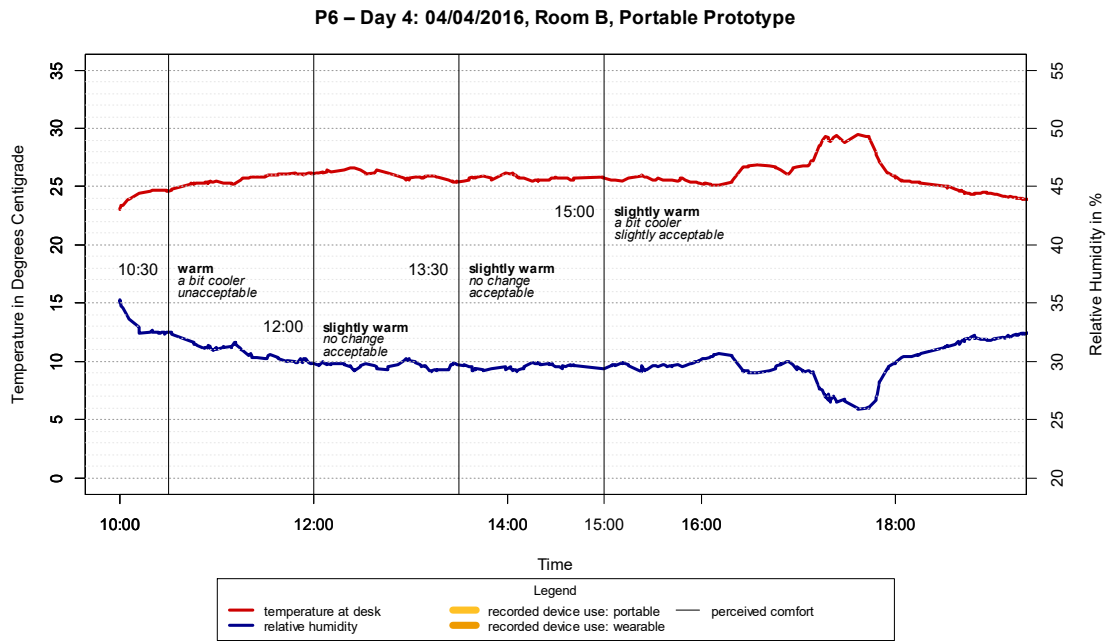
P6 – Day 3: 01/04/2016, Room B, Portable Prototype



Outdoor Weather	
Clothing	long sleeved shirt/top, trousers/long skirt, long socks; boots;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:15	Seated, passive	Room heating on; Drafts from windows/vents;	Cold;	
12:30	Other, "went gym"	Room heating on; Heating system provides too much heating;	Hot;	
14:30	Seated, active	Room heating on;	At room temperature;	
16:00	Walking, outdoors	Room heating on;	Hot;	

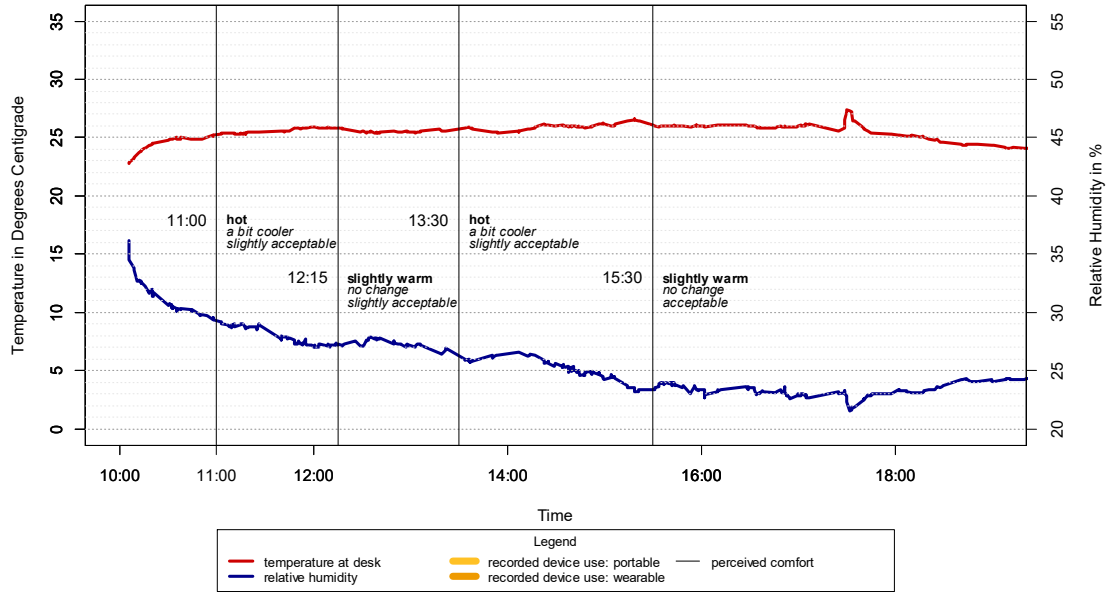
Comments	"Had office to myself all day."
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Outdoor Weather	Clear/sunny to partly cloudy
Clothing	long sleeved shirt/top, vest, trousers/long skirt, short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:30	Walking, outdoors;	Room heating on; Air movement too low; Heating system provides too much heating;	At room temperature;	
12:00	Seated, active;	Room heating on;		
13:30	Seated, active;	Room heating on;	Cold;	
15:00	Walking, indoors;		Hot;	

P6 – Day 5: 05/04/2016, Room B, Both Prototypes

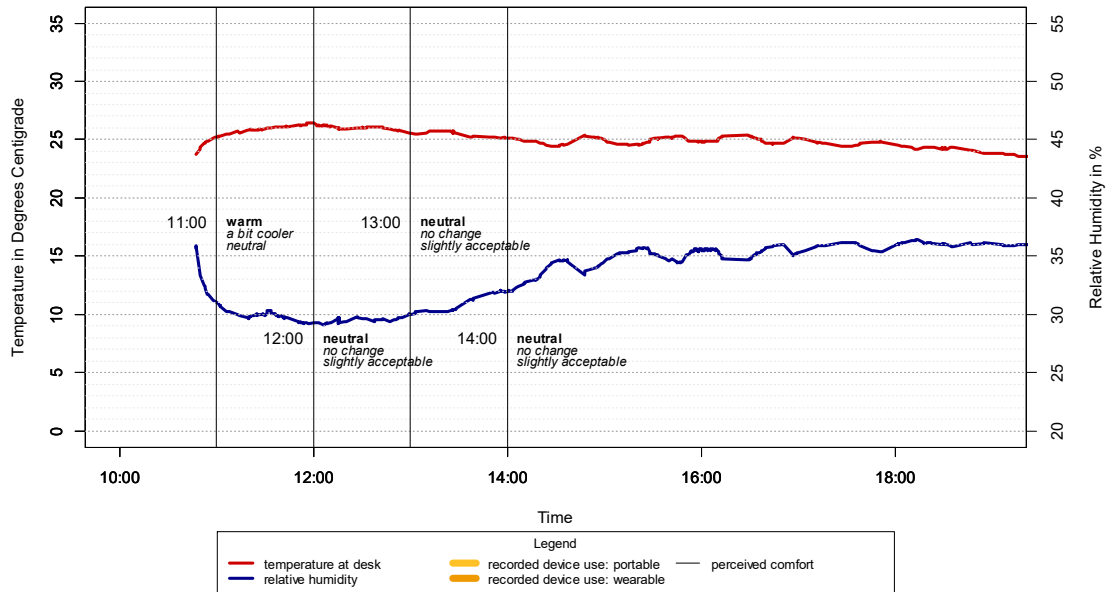


Outdoor Weather	Clear/sunny
Clothing	long sleeved shirt/top, trousers/long skirt, short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:00	Walking, outdoors;	Room heating on;	At room temperature;	
12:15	Seated, active;	Room heating on;		
13:30	Other, "gym"	Room heating on;	Cold	
15:30	Seated, active;	Room heating on;	Cold	

Comments	"Been walking around a lot today - in and out the office."
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P6 – Day 6: 11/04/2016, Room B, Both Prototypes

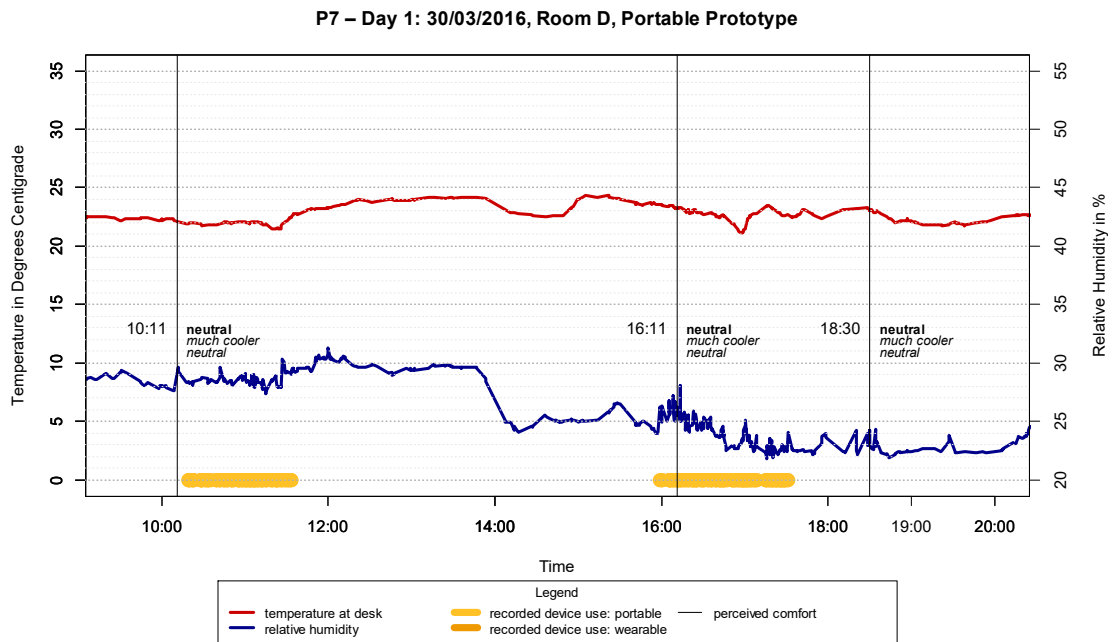


Outdoor Weather	Clear/sunny
Clothing	long sleeved shirt/top, vest, trousers/long skirt, short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:00	Walking, outdoors;	Room heating on;		
12:00	Seated, active;	Room heating on;		
13:00	Seated, active;	Room heating on;	At room temperature;	
14:00	Seated, active;	Room heating on;	Cold;	

Participant A7

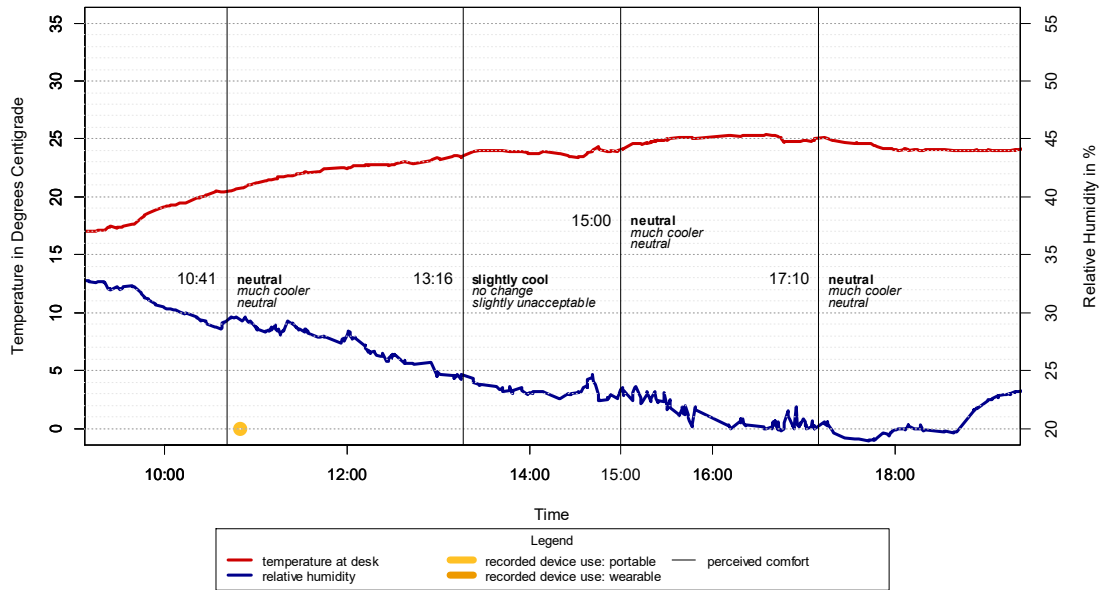
A7 – Day 1, Portable Heating Prototype, Room B, 30/03/2016



Outdoor Weather	Clear/sunny
Clothing	short sleeved shirt/top, jacket, trousers/long skirt, short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:11	Walking, outdoors;	Door open; Room heating on;		Additional item of clothing on: jacket;
16:11	Seated, active;	Door open; Room heating on;		
18:30	Seated, active;	Windows open; Room heating on;		

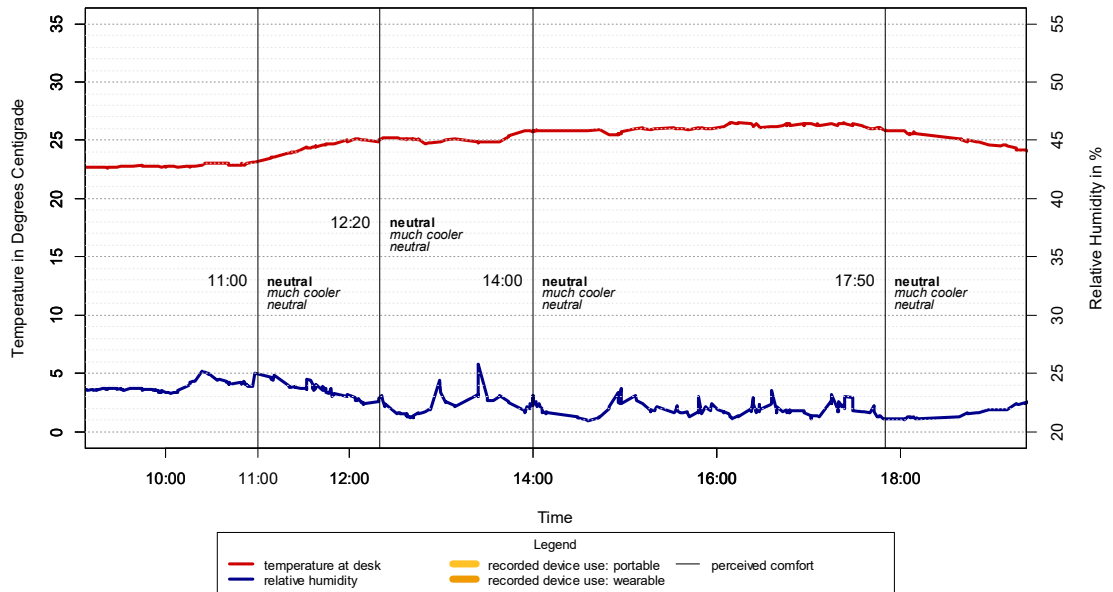
P7 – Day 2: 31/03/2016, Room D, Portable Prototype



Outdoor Weather	Clear/sunny to partly cloudy
Clothing	short sleeved shirt/top, (jumper/cardigan), trousers/long skirt, short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:41	Walking, outdoors;	Air condition on; Room heating on;	hot	
13:16	Seated, active;	Air condition on; Room heating on;		Additional item of clothing on: jumper;
15:00	Standing, active;	Air condition on; Room heating on;		
17:10	Seated, active;	Air condition on; Room heating on;		

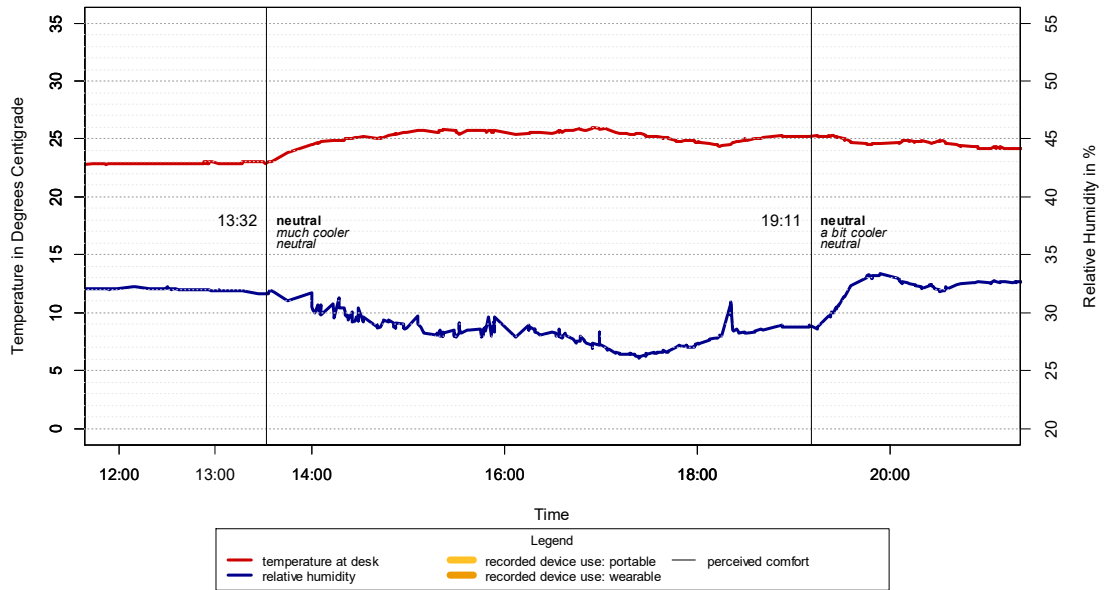
P7 – Day 3: 01/04/2016, Room D, Wearable Prototype



Outdoor Weather	Clear/sunny to partly cloudy
Clothing	short sleeved shirt/top, trousers/long skirt, short socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:00	Seated, active;	Air condition on; Room heating on;	Hot	
12:20	Seated, active;	Air condition on; Room heating on;	Hot	
14:00	Seated, active;	Air condition on; Room heating on;		
17:50	Seated, active;	Air condition on; Room heating on;		

P7 – Day 4: 03/04/2016, Room D, Wearable Prototype



Outdoor Weather	Partly cloudy
Clothing	short sleeved shirt/top, shorts/short skirt, short, (jacket), socks; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
13:32	Walking, outdoors;	Door open; Air condition on; Room heating on; Drafts from windows/vents;	Cold;	
19:11	Walking, outdoors;	Door open; Windows open; Air condition on; Room heating on; Drafts from windows/vents;		Additional item of clothing: jacket;

No data collected

Outdoor Weather	Partly cloudy to cloudy/grey
Clothing	short sleeved shirt/top, trousers/long skirt, (jumper/cardigan); shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:00	Seated, active;	Door open; Air condition on; Room heating on;		Additional item of clothing: jumper/cardigan;
13:37	Walking, outdoors;	Door open; Air condition on; Room heating on;	hot	
15:40	Seated, passive;	Door open; Air condition on; Room heating on;		

No data collected

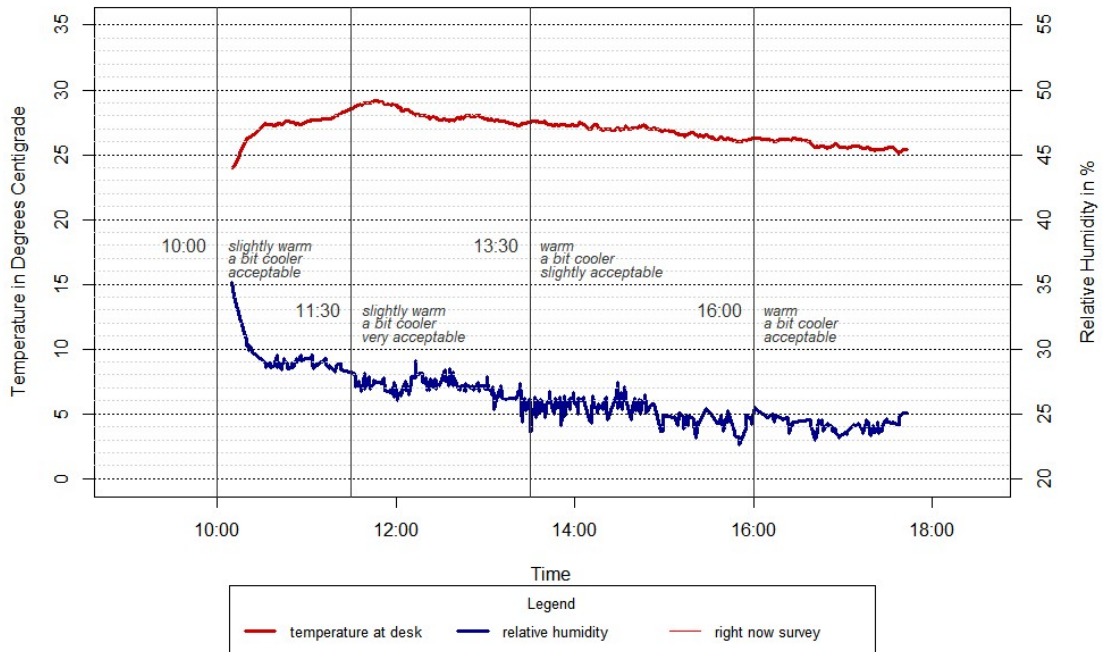
Outdoor Weather	Partly cloudy to clear/sunny
Clothing	short sleeved shirt/top, trousers/long skirt, (jacket); long socks, shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:50	Walking, outdoors;	Door open; Windows open; Air condition on; Room heating on;		Windows, open: “to let fresh air in”
14:29	Walking, indoors;	Windows open; Air condition on; Room heating on;		
16:40	Walking, outdoors;	Windows open; Air condition on; Room heating on;		

Participant A8

A8 – Day 1, Wearable Heating Prototype, Room D, 12/04/2016

P8 – Day 1: 12/04/2016 - Room D - Wearable Heating Prototypes

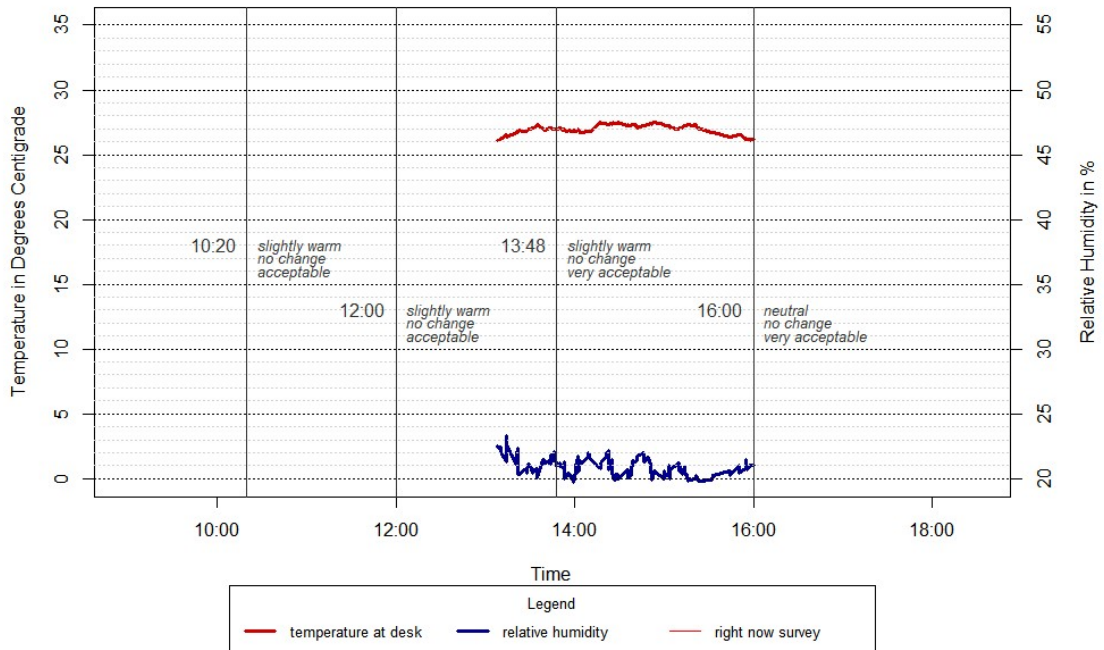


Outdoor Weather	Clear/sunny
Clothing	Short sleeved top/shirt, trousers/long skirt, (jumper/cardigan); shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:00	Seated, passive	“totally closed room; sunlight coming in;”	Hot	
11:30	Seated, active	“totally closed room; sunlight coming in;”		
13:30	Seated, active	Windows open	Hot	Item of clothing off: “I felt hot”
16:00	Seated, active	Windows open	Cold	“it’s okay”

Comments	10am: “I feel like there’s not much air in the room. Plus sunlight coming in, so its warmer than the usual mornings.”
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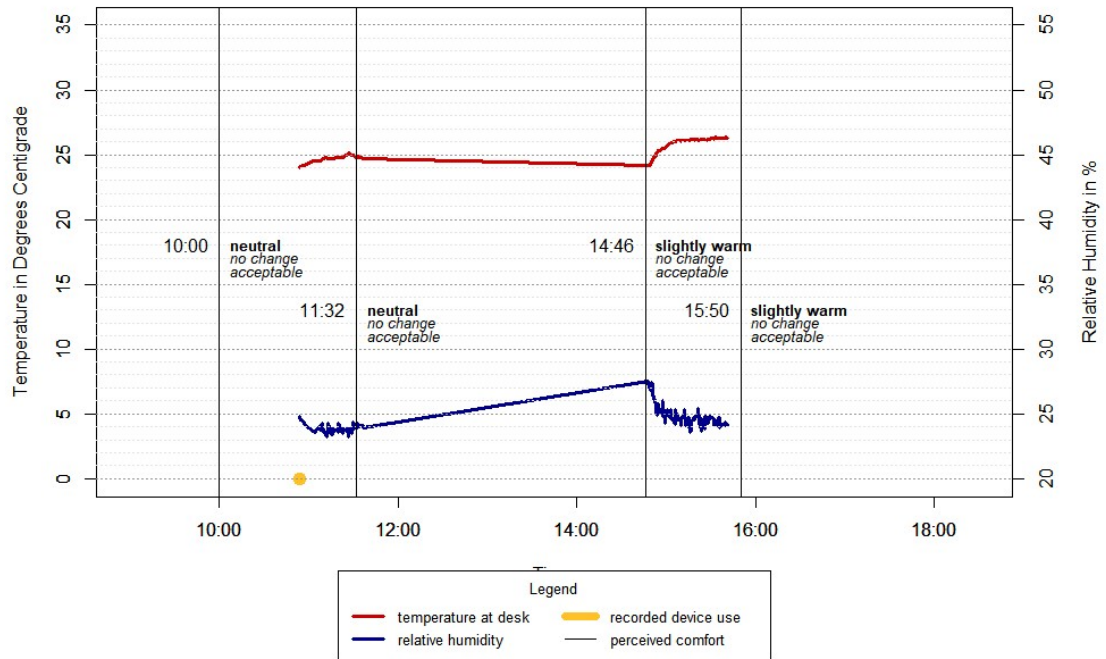
P8 – Day 2: 13/04/2016 - Room D - Wearable Heating Prototypes



Outdoor Weather	Partly cloudy to cloudy/grey
Clothing	Short sleeved top/shirt, trousers/long skirt; shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:20	Seated, active	Windows open		
12:00	Seated, active	Windows open		
13:48	Seated, active	Windows open	cold	
16:00	Seated, active	Windows open		

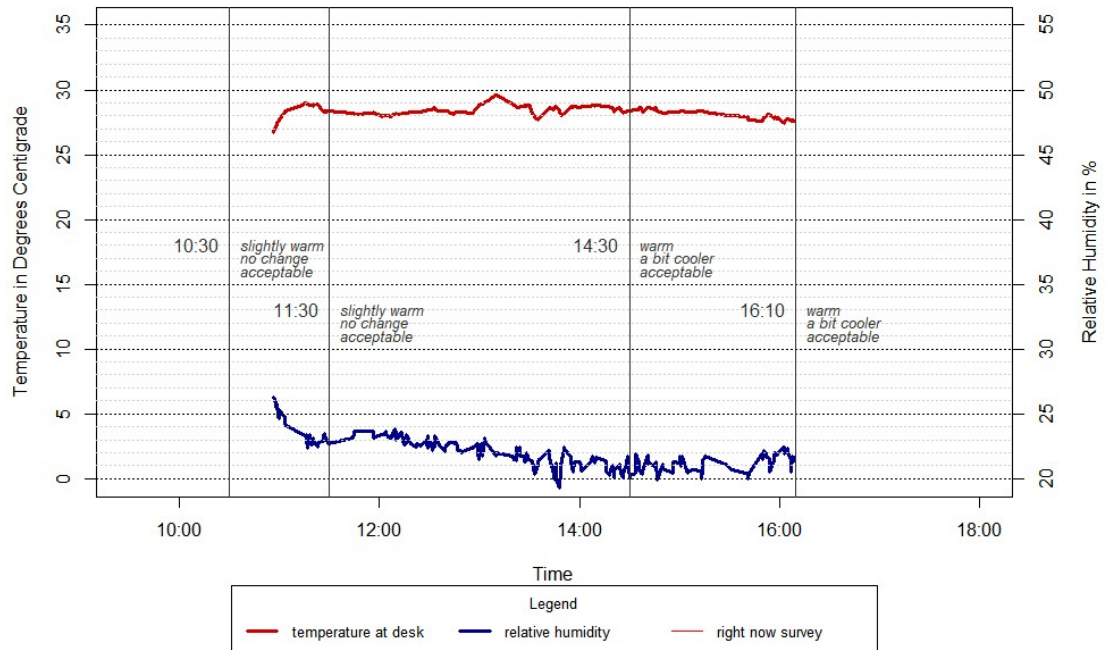
P8 – Day 3: 18/04/2016 - Room D - Portable Heating Prototypes



Outdoor Weather	Cloudy/grey to partly cloudy
Clothing	Short sleeved top/shirt, trousers/long skirt; long socks, shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:00	Seated, active; Walking, indoors; Walking, outdoors;	Lights on; Windows closed;	hot	
11:32	Seated, active	Lights on; Windows closed;		Item of clothing off: "I felt warm"
14:46	Seated, active Walking, indoors; Walking, outdoors;	Lights on; Windows closed;	hot	Item of clothing off: "I felt warm"
15:50	Seated, active	Lights on; Windows closed;		

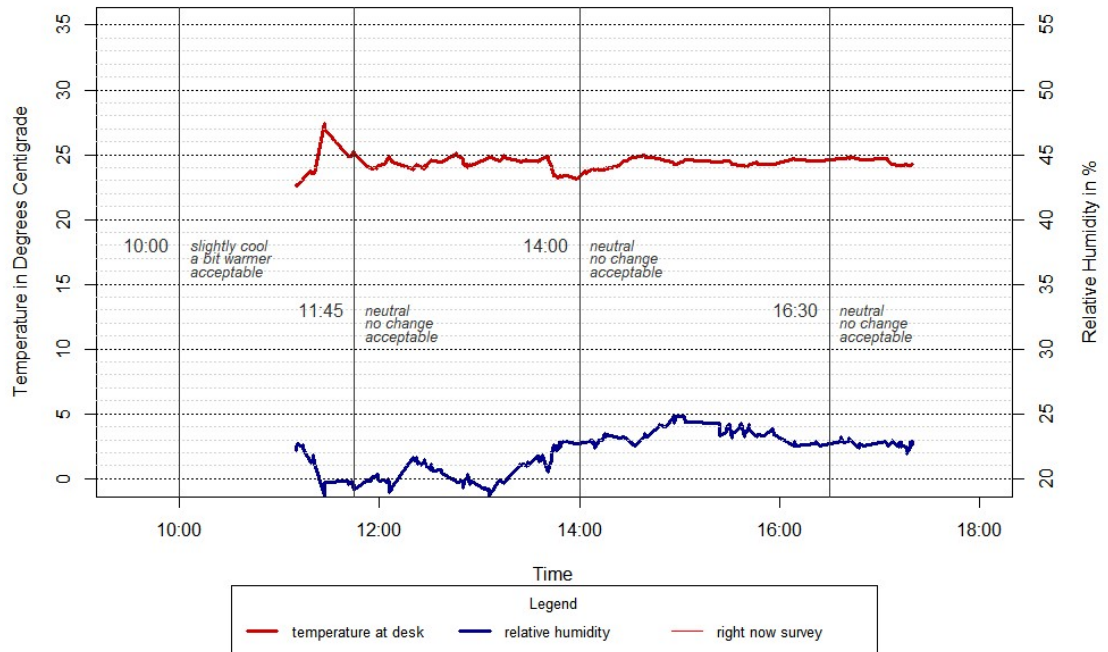
P8 – Day 4: 19/04/2016 - Room D - Wearable Heating Prototypes



Outdoor Weather	Partly cloudy
Clothing	No entry

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:30	No entries			
11:30				
14:30				
16:10				

P8 – Day 5: 26/04/2016 - Room D - Both Prototypes



Outdoor Weather	Partly cloudy to clear/sunny
Clothing	Short sleeved top/shirt, long sleeved top/shirt, trousers, long socks, shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:00	Walking, outdoors;	Lights on;		
11:45	Walking, indoors;	Blinds/curtains down; Lights on;		Additional clothing item: long sleeved shirt
14:00	Seated, active;	Blinds/curtains down; Lights on;	hot	
16:30	Seated, active;	Lights on;		

No data recorded

Outdoor Weather	Partly cloudy to cloudy/grey, rainy and snowy
Clothing	Short sleeved top/shirt, long sleeved top/shirt, trousers, long socks, shoes;

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:30	Walking, outdoors;	Lights on;		Item of clothing, off: “my coat because not comfy.”; Prototype, on: “Prototype to warm up quickly”
12:00	Standing, active;	Lights on;	hot	
14:00	Walking, outdoors;	Lights on;	hot	Item of clothing, off: “my coat because not comfy.”; Prototype, on: “Prototype to warm up quickly”
16:00	Walking, indoors;	Lights on;	At room temperature	

Participant A9

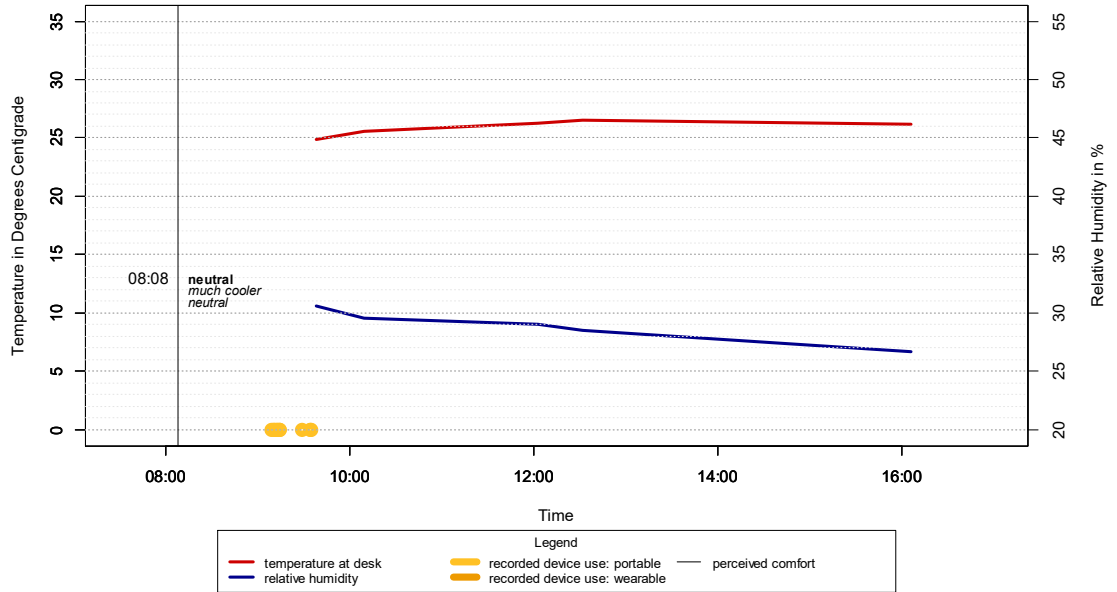
A9 – Day 1, Portable Heating Prototype, Room E, 11/04/2016

Outdoor Weather	Clear/sunny (10:30, cloudy/grey (11:42)
Clothing	Long sleeved shirt/top, Trousers/long skirt, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:30	Seated (active)	air movement too high/low Window(s) open, Lights on	Room Temperature	Prototype (on) I felt cool
11:42	Seated (active)	Cold surrounding surfaces Window(s) open, Lights on	Room Temperature	Prototype (on) I felt cool

Comments	
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P9 – Day 2: 12/04/2016, Room E, Portable Prototype

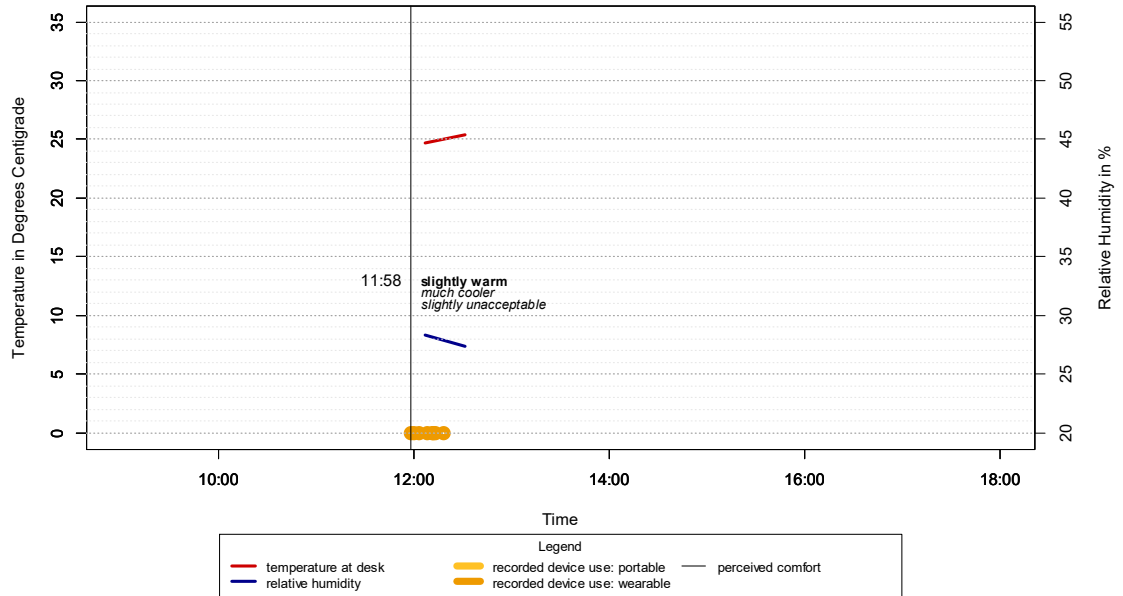


Outdoor Weather	Cloudy/grey
Clothing	Dress, Tights/legging, Boots

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
08:08	Walking (outdoors)	air movement too high/low Lights on	Room Temperature	Prototype (on) Other (I got a cold)

Comments	
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P9 – Day 3: 13/04/2016, Room E, Wearable Prototype

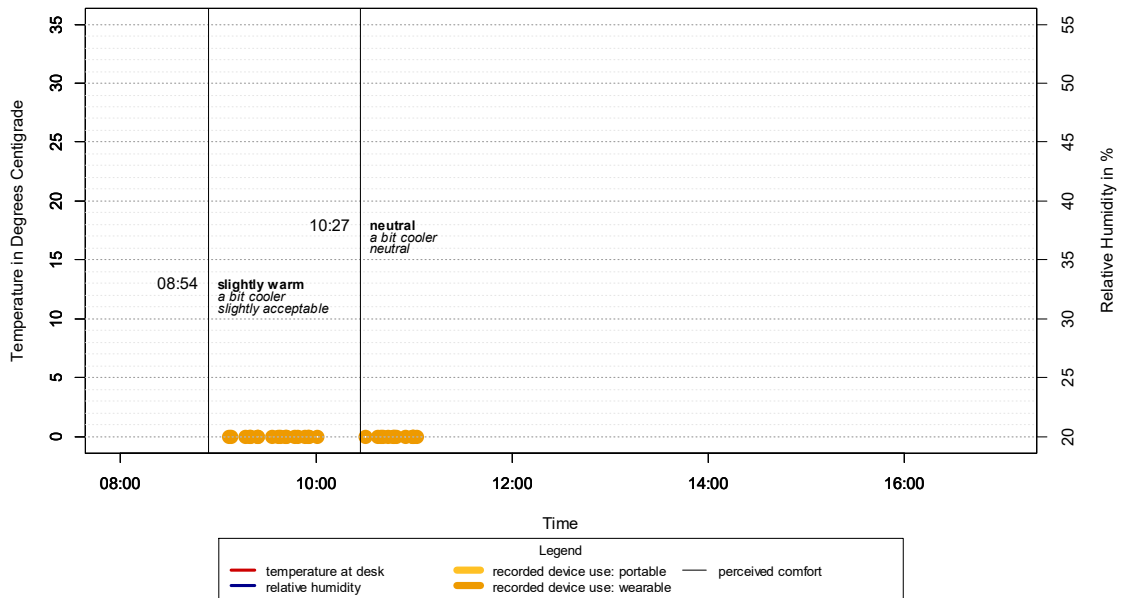


Outdoor Weather	Clear/sunny
Clothing	Long sleeved shirt/top, Trousers/long skirt, Long socks

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:58	Walking (outdoors)	air movement too high/low Window(s) open	Room Temperature	Prototype (on) Other (I have a cold)

Comments	
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P9 – Day 4: 18/04/2016, Room E, Wearable Prototype

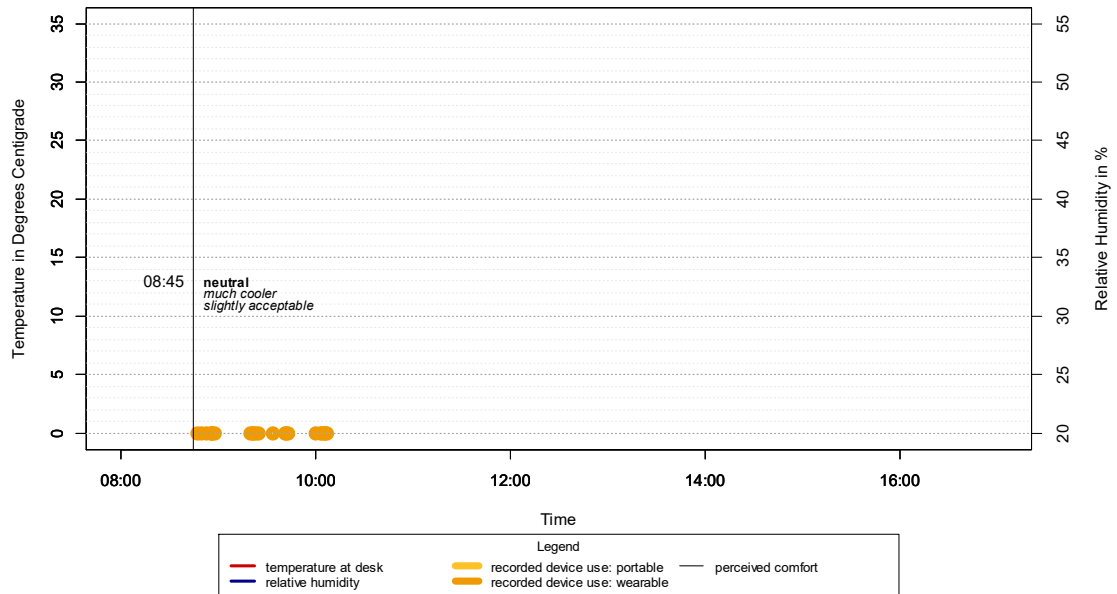


Outdoor Weather	Clear/sunny
Clothing	Long sleeved shirt/top, Dress, Long socks

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
08:54	Walking (outdoors)	air movement too high/low (too low) Window(s) open	Room Temperature	Prototype (on) I felt cold (just for my legs)
10:27	Walking (outdoors)	Hot surrounding surfaces Window(s) open	Room Temperature	Prototype (on) I felt cold (just for my legs)

Comments	
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P9 – Day 5: 19/04/2016, Room E, Both Prototypes



Outdoor Weather	Cloudy/grey
Clothing	Long sleeved shirt/top, Trousers/long skirt

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
08:45	Walking (outdoors)	air movement too high/low Window(s) open, Lights on	Room Temperature	Prototype (on), Window(s) (open) Other (just wanted warmer)

Comments	8:45 use scarf prototype
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A9 – Day 6, Portable and Wearable Heating Prototype, Room E, 20/04/2016

No data recorded

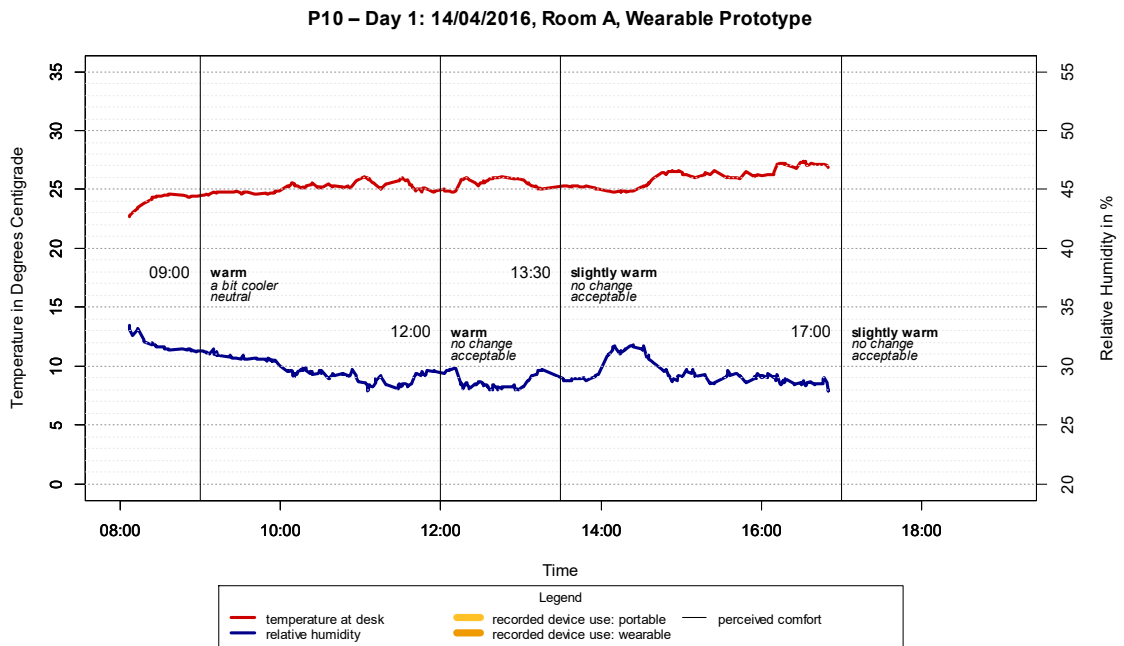
Outdoor Weather	Partly cloudy
Clothing	Short sleeved shirt/top, Dress, Long socks

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:38	Walking (indoors)	Other (temperature difference in office and outside) Window(s) open	Room Temperature	Prototype (on), Window(s) (open) I felt cold

Comments	9:38 use scarf prototype
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Participant A10

A10 – Day 1, Wearable Heating Prototype, Room A, 14/04/2016

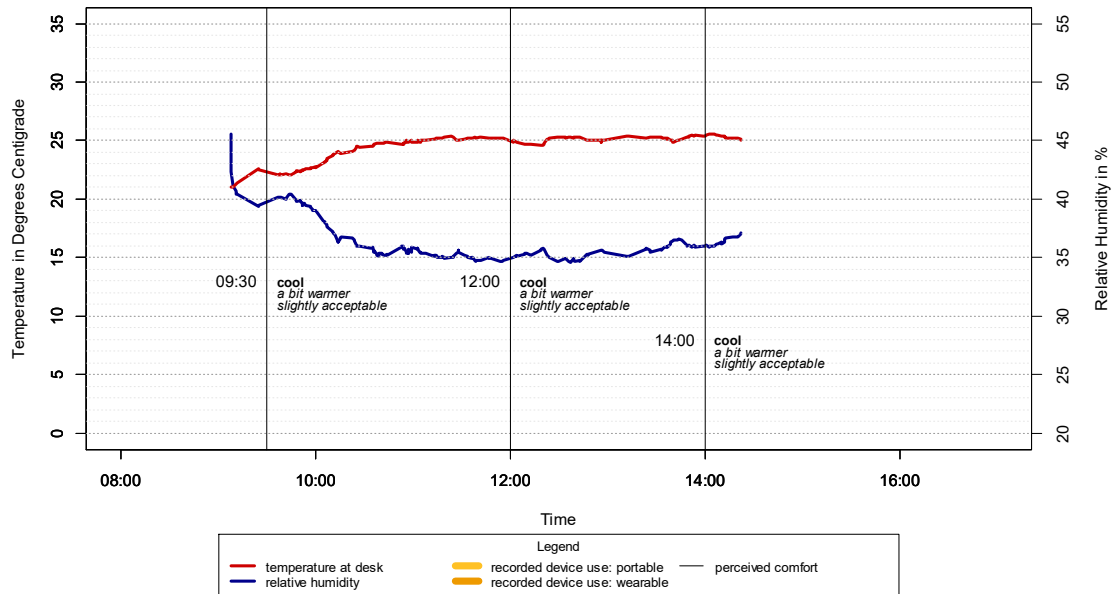


Outdoor Weather	Partly cloudy
Clothing	Short/Long sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:00	Other (Cycling)	air movement too high/low (too low) Window(s) open, Lights on, Room heating on		Heating (down), Window(s) (open) I felt hot, Other (stale air/ no movement)
12:00	Seated (active)	air movement too high/low (too low) Door open, Window(s) open, Lights on, Room heating on		
13:30	Seated (active)	air movement too high/low (too low) Door open, Window(s) open, Lights on	Hot	
17:00	Seated (active)	air movement too high/low (too low) Door open, Window(s) open, Lights on		

Comments	Participant forgot to fill in the time of recording (filled in retrospectively)
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P10 – Day 2: 15/04/2016, Room A, Wearable Prototype

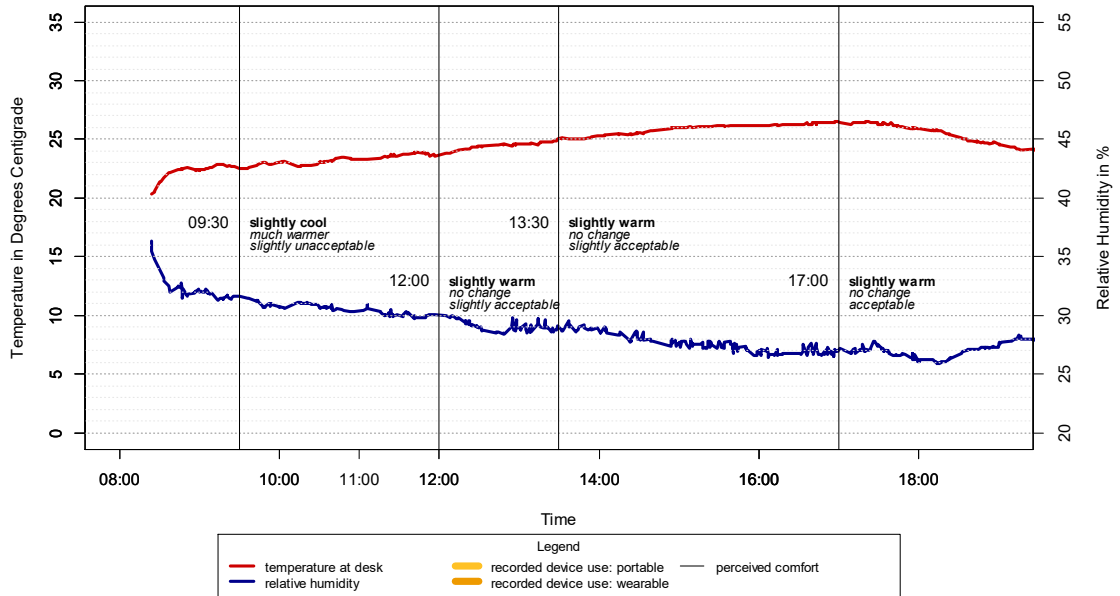


Outdoor Weather	Cloudy/grey
Clothing	Long sleeved shirt/top, Trousers/long skirt, Long socks,Short socks,Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:30	Seated (active)	Draughts from windows/vents Door open, Lights on		Window(s) (close) I felt cool
12:00	Seated (active)	Lights on		
14:00	Seated (active)	Lights on	Hot	Prototype (on) I felt cool

Comments	Participant forgot to fill in the time of recording (filled in retrospectively)
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P10 – Day 3: 20/04/2016, Room A, Portable Prototype

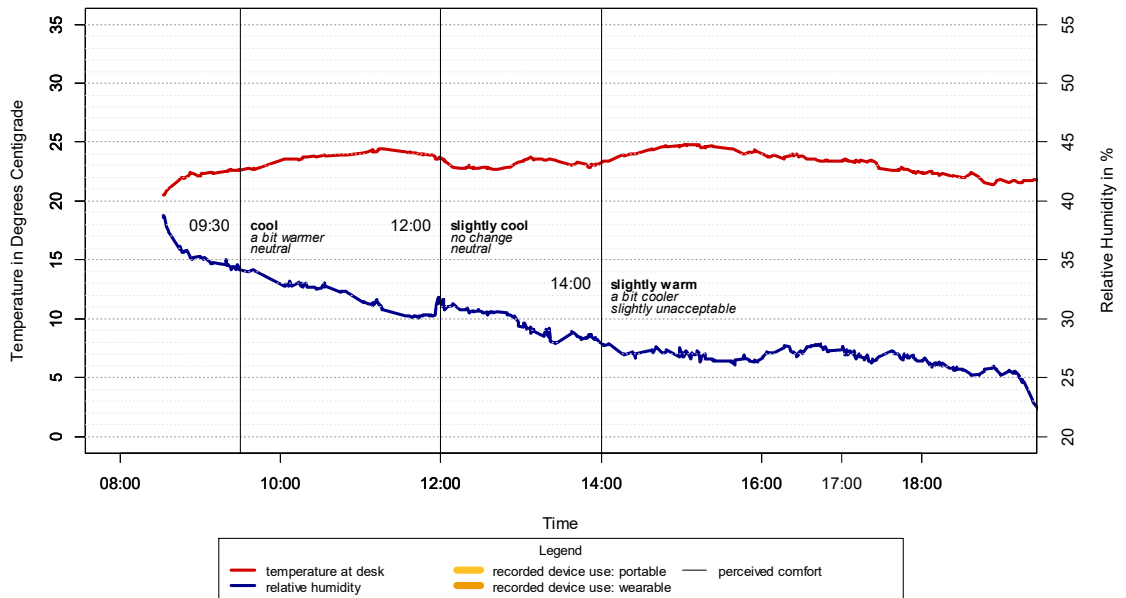


Outdoor Weather	Partly cloudy
Clothing	Short sleeved shirt/top, Trousers/long skirt, Long socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:30	Seated (passive)	Draughts from windows/vents Lights on, Air condition on, Room heating on		
12:00	Seated (active)	Lights on, Air condition on, Room heating on		
13:30	Walking (outdoors)	Window(s) open, Lights on, Air condition on, Room heating on	Hot	Window(s) (open) I felt warm
17:00	Seated (active)	Lights on, Air condition on, Room heating on		Window(s) (close) I felt cool

Comments	
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P10 – Day 4: 21/04/2016, Room A, Portable Prototype

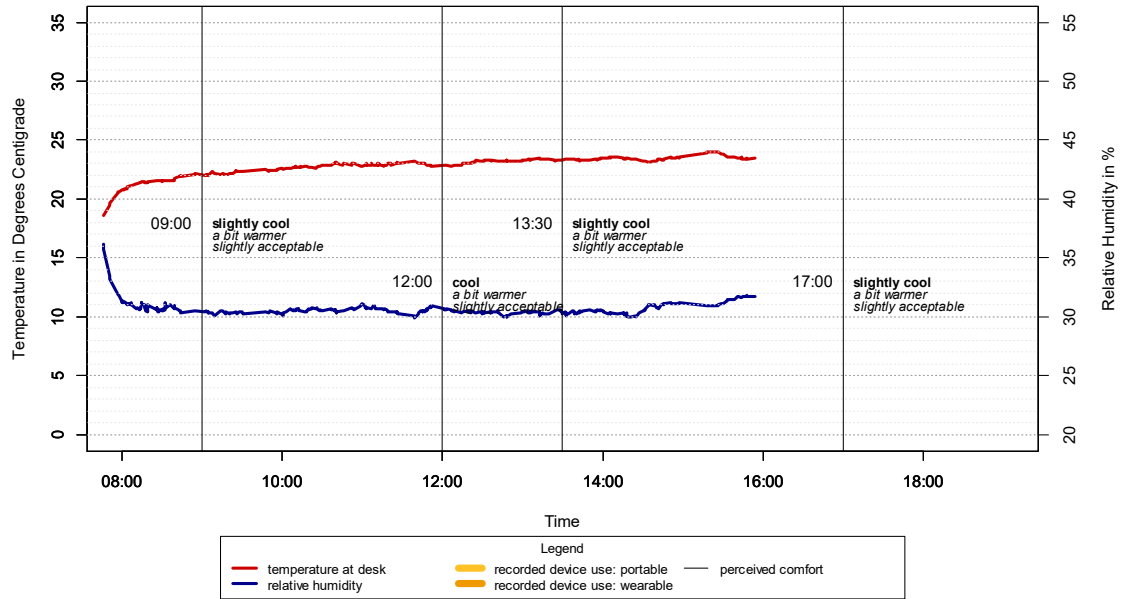


Outdoor Weather	Cloudy/grey
Clothing	Short sleeved shirt/top, Long sleeved shirt/top, Trousers/long skirt, Long socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:30	Seated (passive)	Lights on, Air condition on, Room heating on		
12:00	Seated (active)	Lights on, Air condition on, Room heating on		
14:00	Walking (indoors)	air movement too high/low (too low) Window(s) open, Lights on, Air condition on, Room heating on	Hot	Window(s) (open) Other (air movement)

Comments	
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P10 – Day 5: 25/04/2016, Room A, Both Prototypes



Outdoor Weather	Cloudy/grey, Drizzly (12:00)
Clothing	Short sleeved shirt/top, Long sleeved shirt/top, Trousers/long skirt, Long socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:00	Seated (passive)	Lights on		
12:00	Seated (active)	Heating system provides not enough heating Lights on		Prototype (on) I felt cool
13:30	Seated (active)	Heating system provides not enough heating Lights on	Hot	Prototype (on) I felt cool
17:00	Seated (active)	Lights on		

Comments	
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No data recorded

Outdoor Weather	Rainy
Clothing	Short sleeved shirt/top, Long sleeved shirt/top, Trousers/long skirt, Long socks, Boots

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
09:30	Seated (passive)	Heating system provides not enough heating Lights on, Room heating on		
11:30	Seated (active)	Heating system provides not enough heating Lights on, Room heating on		Prototype (on) I felt cool
14:20	Seated (active)	Heating system provides not enough heating Lights on, Room heating on		Prototype (on) I felt cool

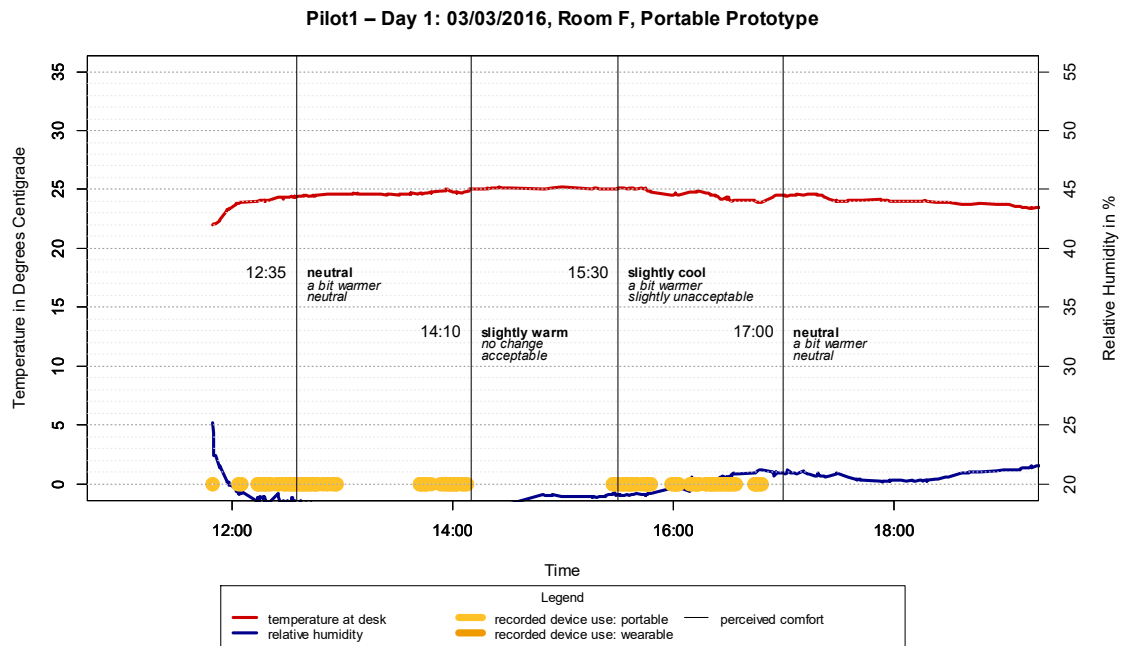
Comments	
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Participant A11

Participant A11 claimed his comfort did not change over the day. No data was recorded.

Pilot1

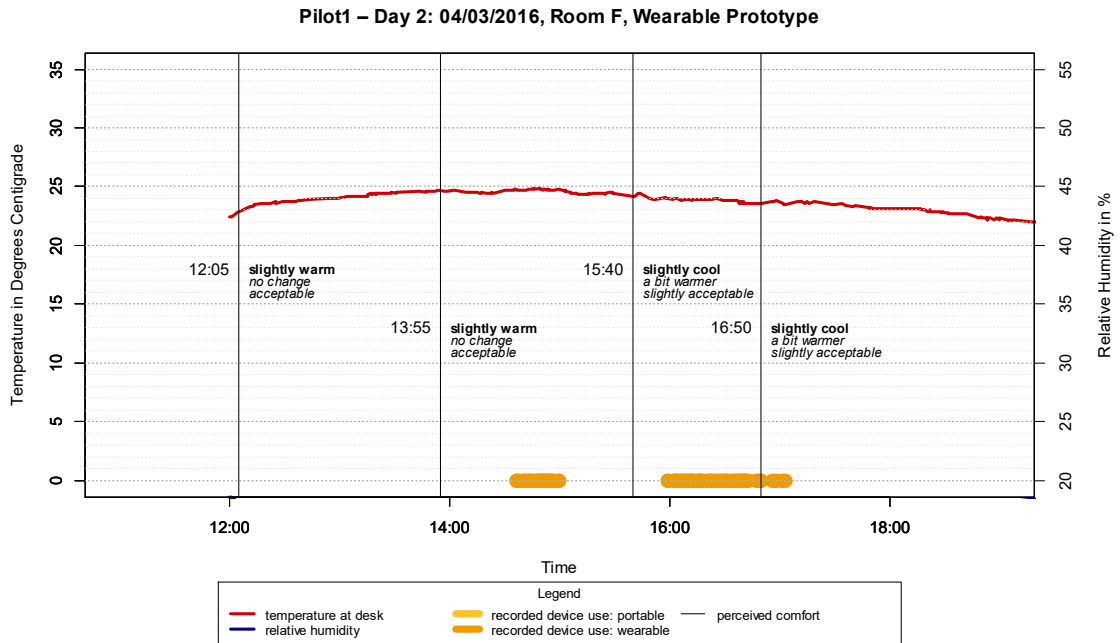
Pilot1 – Day 1, Portable Heating Prototype, Room F, 03/03/2016



Outdoor Weather	Clear/sunny to partly cloudy
Clothing	Dress, Jumper/cardigan/sweatshirt, Tights/legging, Long socks, Boots

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:35	Seated (passive)	Cold surrounding surfaces Lights on, Room Heating on	Room temperature	
14:10	Seated (active)	Incoming sun Lights on, Room Heating on	Hot	move sleeves up
15:30	Seated (passive)	Draughts from windows/vents Lights on, Room Heating on	Room temperature	move sleeves down
17:00	Seated (passive)	Hot surrounding surfaces Lights on, Room Heating on	Room temperature	

Pilot1 – Day 2, Wearable Heating Prototype, Room F, 04/03/2016

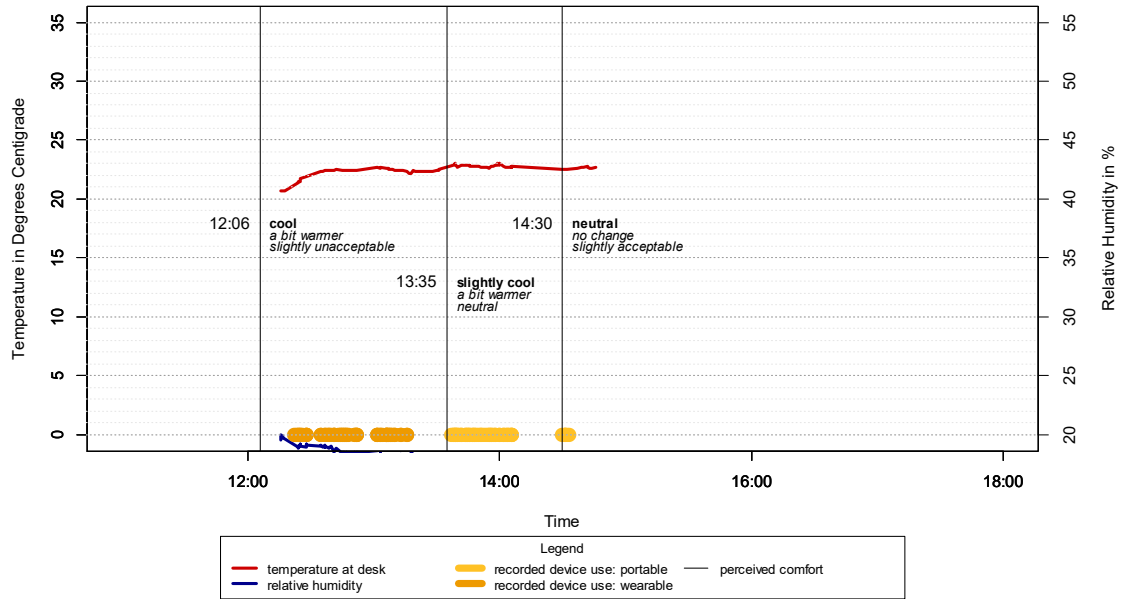


Outdoor Weather	Clear/sunny to partly cloudy
Clothing	Short sleeved shirt/top, Trousers/long skirt, Jumper/cardigan/sweatshirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:05	Seated (active)	Lights on, Room Heating on	Room temperature	
13:55	Seated (passive)	Lights on, Room Heating on, Fan on	Room temperature, Hot	
15:40	Seated (passive)	Hot surrounding surfaces Lights on, Room Heating on, Fan on	Room temperature	
16:50	Seated (active), Walking (indoors)	Hot surrounding surfaces Lights on, Room Heating on, Fan on	Room temperature	

Comments	
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Pilot1 – Day 3: 07/03/2016, Room F, Both Prototypes



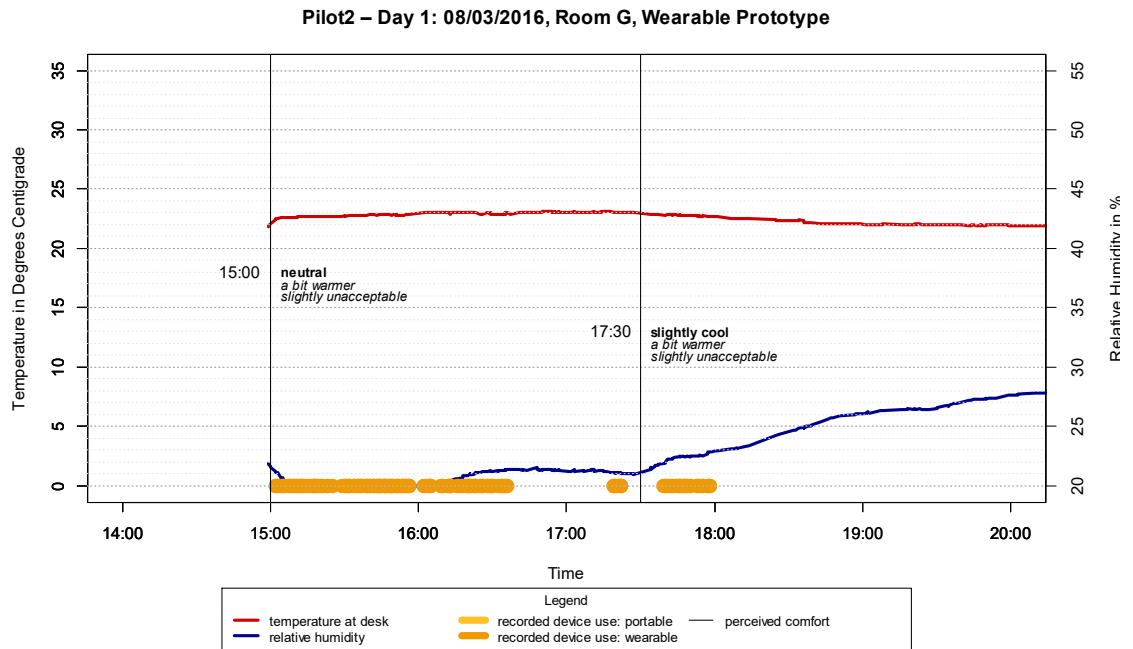
Outdoor Weather	Clear/sunny
Clothing	Vest, Dress, Tights/legging, Boots

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:06	Seated (passive)	Hot surrounding surfaces Window(s) open, Room Heating on	Room temperature	
13:35	Seated (passive)	Draughts from windows/vents Window(s) open, Room Heating on	Room temperature	
14:30	Seated (active)	Window(s) open, Room Heating on	Room temperature	

Comments	
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Pilot2

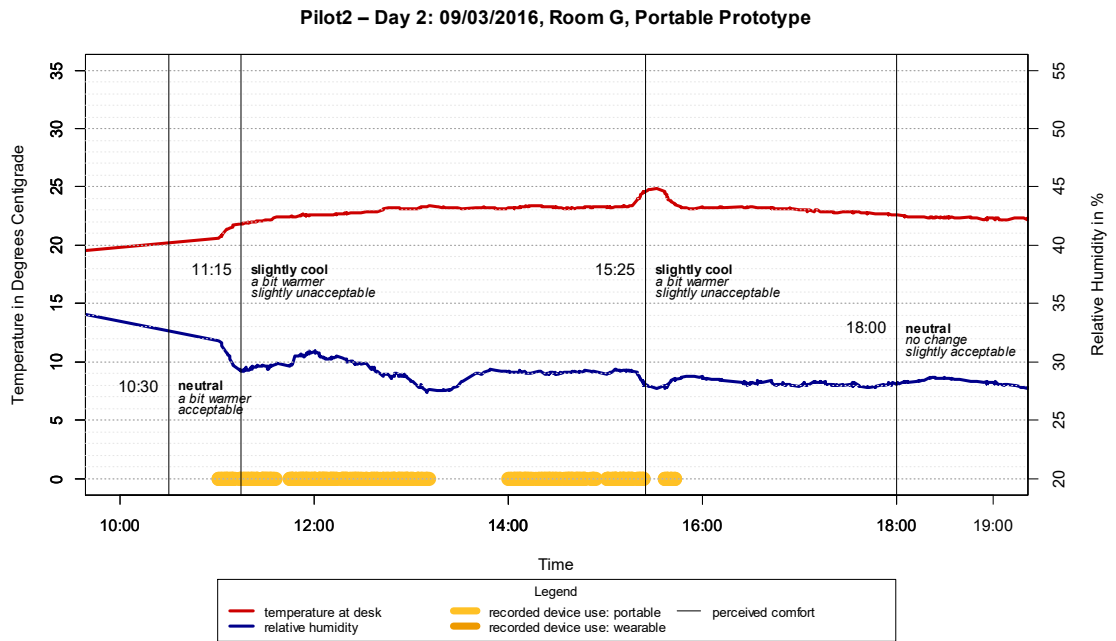
Pilot2 – Day 1, Wearable Heating Prototype, Room G, 08/03/2016



Outdoor Weather	Cloudy/grey, Rainy
Clothing	Dress, Jumper/cardigan/sweatshirt, Tights/legging, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
15:00	Seated (active)	Cold surrounding surfaces Lights on, Room Heating on		
17:30	Seated (passive)	Draughts from windows/vents Lights on, Room Heating on		

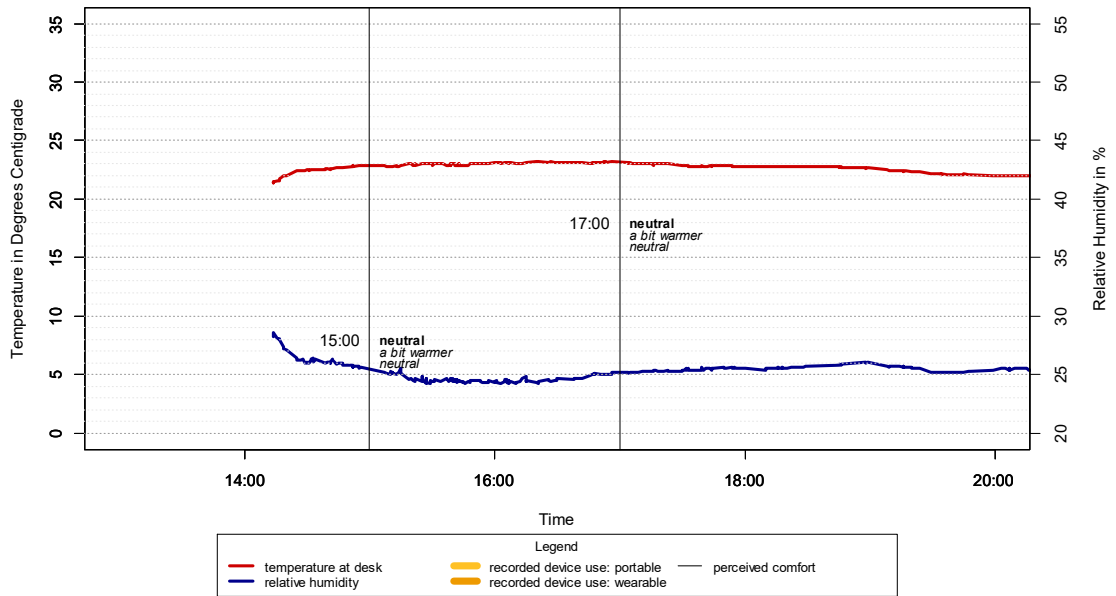
Comments	
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Outdoor Weather	Drizzly, Cloudy/grey
Clothing	Short sleeved shirt/top, Trousers/long skirt, Jumper/cardigan/sweatshirt, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
10:30	Walking (indoors)	Draughts from windows/vents Lights on, Room Heating on		
11:15	Seated (passive)	Draughts from windows/vents Lights on, Room Heating on		
15:25	Seated (passive)	Draughts from windows/vents, Cold surrounding surfaces Lights on, Room Heating on		
18:00	Seated (active)	Draughts from windows/vents Lights on, Room Heating on		item of clothing on

Pilot2 – Day 3: 10/03/2016, Room G, Both Prototypes



Outdoor Weather	Cloudy/grey
Clothing	Dress, Jumper/cardigan/sweatshirt, Tights/legging, Boots

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
15:00	Seated (active)	Draughts from windows/vents Lights on, Room Heating on		
17:00	Seated (active)	Draughts from windows/vents Lights on, Room Heating on		

Appendix E

Materials User Study on Personal Cooling Prototype

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E.1. Information Sheet

Information Sheet

Research study “Microatmospheres: Personal Heating/Cooling Devices”: Information for Participants

We would like to invite you to be part of this research project, in which we are looking at people’s individual comfort in shared, open-plan work environments and at possibilities to improve it using a personal cooling devices. Please read the following information carefully before you decide to take part; this will tell you why the research is being done and what you will be asked to do if you take part. Please ask if there is anything that is not clear or if you would like more information.

If you do decide to take part, you will be given this information sheet to keep and be asked to sign the attached consent form to say that you agree. You are still free to withdraw at any time and without giving a reason.

In the scope of this study we will present a personal cooling prototype to you in two different control conditions and ask you to use it as you feel appropriate at your workplace. We will ask you to provide feedback on your use and the usability of the prototype as well as on your thermal comfort throughout the test period.

This study is laid out as follows:

First, we will assess the overall conditions and your general comfort in your workplace. We will ask you to fill out a **questionnaire**, which will look at your experiences with and your perception of comfort in your workplace environment at the School of Electronic Engineering and Computer Science, Queen Mary University of London. This session will take about 10 to 15 minutes.

In addition, we will install **sensor nodes** at your workspace, which will take the following environmental readings: temperature, humidity, light levels, and air movement. The sensor nodes will stay installed throughout the study. As they are battery driven, we might have to access them every now and then for charging or will provide you with spare batteries.

Next, a **cooling prototype** in one of two control conditions will be given to you, which you can use during your working day to improve your felt comfort. At the beginning we will briefly explain to you how the prototype works and how it is controlled. You will have the device at your disposal **for two working days** after which we will **change the control condition** and make it available to you **for another two days**.

During this time, we would like you to fill out a **questionnaire four times a day**, which asks about your feeling of comfort “right now”. Ideally this would happen 15 minutes after you have arrived in the office, about two hours afterwards or before you go for your lunch break, in the

middle of the afternoon, and at the end of your working day, i.e. before you leave. Also, we would like to ask you to put down in the comment section of the questionnaire any particular changes in perception, adaptive behaviours, or changes of comfort or discomfort you become aware of in relation to environmental temperature, other people's actions or devices, any personal devices you use or your use of them. We will ask you to report on your comfort in this way on each working day of the study.

At the end of the test period for a control condition, we would like to ask you to reflect on your use of and satisfaction with the device and its control and fill out a very brief **evaluation questionnaire**.

To conclude the study, you will be given **the cooling prototype for another two working days** during which you will be able to choose in between both control conditions freely. We will ask you also to fill out **right now comfort questionnaires four times a day** as well as an **evaluation questionnaire** at the end as described previously. After the two working days with both control conditions available, we will conduct a brief **interview** about your experiences with our prototype. The interview will be video recorded.

The video recording will be transcribed and is for documentation and analysis purposes only. Please let us know if you do not feel comfortable to be recorded.

No other use will be made of any video or audio content as well as any pictures taken of you without your written permission, and no one outside the project will be allowed access to the original recordings.

All the information we collect about you during the course of the research will be kept strictly confidential. You will not be able to be identified in any reports or publications.

If you have any questions, please let us know. If any questions should come up during the study, please do not hesitate to approach us.

It is entirely up to you to decide whether or not to take part. There are no disadvantages attached if, at any time, you choose not to take part or decide to withdraw from the study.

If you have any questions or concerns about the manner in which the study was conducted please, in the first instance, contact the researcher responsible for the study, Katja Knecht, on k.knecht@qmul.ac.uk or by phone: 07415 714788

If this is unsuccessful, or not appropriate, please contact the Secretary at the Queen Mary Ethics of Research Committee, Room W117, Queen's Building, Mile End Campus, Mile End Road, London or research-ethics@qmul.ac.uk.

E.2. Questionnaires

Thermal Comfort Assessment Questionnaire

In the following questionnaire we would like to get to know how comfortable you feel and how satisfied you are with different indoor environmental parameters at your workplace at QM. In addition, we would like to get to know about your individual thermal background and preferences, what you usually do to achieve thermal comfort at home and in the office.

Section 1: Background Information

1.1. What is your age?

1.2. What is your gender?

Female

Male

1.3. Which of the following best describes your workspace?

Cubicle with high partitions (about 1.5m high)

Cubicle with low partitions (lower than 1.5m high)

Desk space in an open-plan office

Other, please describe:

1.4. How many desks are in your office?

1.5. How many people usually work in your office?

1.6. For how many months or years have you been working in your current office?

1.7. How many days a week are you usually working in your office at QM?

1.8. How much time do you spend on average at your desk when you are in?

Section 2: Workplace Satisfaction

On a scale from 1 (very dissatisfied) to 7 (very satisfied), please let us know how satisfied you are with the following aspects of your work space:

		Very Dissatisfied		Neutral			Very Satisfied		Does not apply
		1	2	3	4	5	6	7	
2.1.	The amount of space available for individual work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.2.	The level of visual privacy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.3.	The ease of interaction with colleagues	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.4.	The comfort of the workspace furnishings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.5.	The temperature	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.6.	The level of personal control over your local thermal environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.7.	The air quality (i.e. stuffy/stale air, cleanliness, odours)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.8.	The level of personal control over the indoor air quality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.9.	The amount of light	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.10.	The visual comfort of the lighting (e.g., glare reflections, contrast)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.11.	The level of personal control over the lighting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.12.	The noise level	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.13.	The sound privacy (e.g. ability to have conversations without your neighbours overhearing & vice versa)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
2.14.	The cleanliness of the workspace	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>

2.15. All things considered, how satisfied are you with your workspace?

Very Dissatisfied Dissatisfied Slightly Dissatisfied Neutral Slightly Satisfied Satisfied Very Satisfied

2.16. Please estimate how much you think your productivity is increased or decreased by the environmental conditions in this building (e.g. thermal, lighting, acoustics, cleanliness):

Decreased Increased

-20% -10% -5% 0% +5% +10% +20%

2.17. If you have any comments regarding your satisfaction with specific workplace parameters or your overall comfort, please let us know.

Section 3: Thermal Comfort

3.1. Which of the following can you personally adjust or control in your workspace? (Please check all that apply. In case any of the devices are your own and not provided by the department, please indicate.)

- Operable window
- Window blinds or shades
- Thermostat
- Portable heater
- Permanent heater
- Room air-conditioning unit
- Portable fan
- Adjustable air vent in wall or ceiling
- Adjustable floor air vent (diffuser)
- Door to interior space
- Door to exterior space
- None of the above
- Other, please describe: _____

a If you are dissatisfied with the level of personal control, what would you wish for?

3.2. How is the temperature in your workspace controlled and who decides?

3.3. In case you are dissatisfied with the workplace temperature, which of the following contribute to your dissatisfaction?

a In warm/hot weather, the temperature in my workspace is: (Please check all that apply)

- Often too hot
- Often too cold
- I have not experienced a warm period in this room yet

b In warm/hot weather... (Please check all that apply)

- My hands are too warm
- My feet are too warm
- Other, please describe: _____

c When is this most often a problem? (Please check all that apply)

- Morning (before 11am)
- Mid-day (11am – 2pm)
- Afternoon (2pm – 5pm)
- Evening (after 5pm)
- Weekends/holidays
- Monday mornings
- No particular time
- Other, please describe: _____

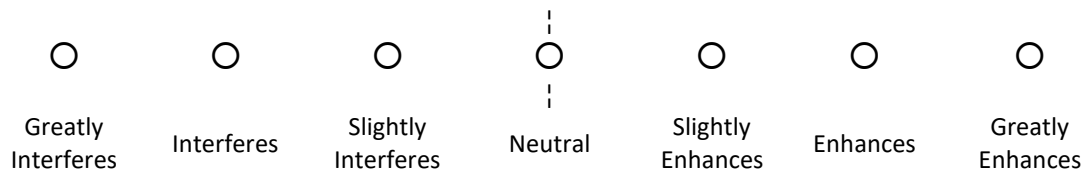
d How would you best describe the source of this discomfort? (Please check all that apply)

- Air movement too high (draughty)
- Air movement too low (stuffy)
- Drafts from windows
- Drafts from vents
- Drafts falling from the ceiling

- Heat from office equipment
- Heating/cooling system does not respond quickly enough to the thermostat
- Hot/cold floor surfaces
- Hot/cold ceiling surfaces
- Hot/cold wall surfaces
- Hot/cold window surfaces
- Humidity too high (damp)
- Humidity too low (dry)
- Incoming sun
- My area is hotter than other areas
- My area is colder than other areas
- Thermostat is inaccessible
- Thermostat is adjusted by other people
- Other, please describe: _____

e Please describe any other issues related to being too hot or too cold in your workspace

3.4. Overall, does your thermal comfort in your workspace enhance or interfere with your ability to get your work done?



Section 4: Individual Thermal Comfort and Behavioural Adjustments

4.1. Would you call yourself a person who easily feels cold, or easily feels too warm, or neither?

4.2. What do you do or how do you adjust to the temperature in the office **if you feel hot?** *(If applicable, please let us know briefly which devices you use, if you put on/off specific items of clothing, if you make adjustments to the environment, or if you aware of any other behavioural adjustments)*

4.3. What do you do or how do you adjust to the temperature in the office **if you feel cold**? *(If applicable, please let us know briefly which devices you use, if you put on/off specific items of clothing, if you make adjustments to the environment, or if you aware of any other behavioural adjustments)*

4.4. Please describe the challenges you face in achieving thermal comfort in your workplace in your own words:

Thank you very much for your participation!

Right Now Thermal Comfort Survey

The following questions refer to the current conditions and the level of comfort as you perceive it at the time you answer this questionnaire. Please reply accordingly and tell us how you feel right now.

Date: _____ Room: _____

Time : : : :

1. How would you describe the weather outside?

Clear/sunny				
Partly cloudy				
Cloudy/Grey				
Drizzly				
Rainy				
Humid				
Other (please specify)				

a) How would you describe the weather today in comparison to yesterday?

Time : : : :

2. How do you feel right now?

Cold				
Cool				
Slightly Cool				
Neutral				
Slightly Warm				
Warm				
Hot				

3. Would you like to be

Much cooler				
A bit cooler				
No change				
A bit warmer				
Much warmer				

Time : : : :

4. How acceptable is the room temperature to you?

Very unacceptable				
Unacceptable				
Slightly unacceptable				
Neutral				
Slightly acceptable				
Acceptable				
Very acceptable				

5. If you are dissatisfied, how would you best describe the source of your discomfort?

Air movement too high / too low				
Incoming sun				
Drafts from windows / vents				
Hot surrounding surfaces (floor, ceiling, walls)				
Cold surrounding surfaces (floor, ceiling, walls)				
Air condition provides too much cooling				
Air condition provides not enough cooling				
Personal device provides too much cooling				
Personal device provides not enough cooling				
Other (please specify)				

6. Please indicate which of the following layers of clothing you are wearing right now:

Short sleeved shirt/top				
Long sleeved shirt/top				
Vest/sleeveless top				
Trousers/long skirt				
Shorts/short skirt				
Dress				
Jumper/Cardigan/Sweatshirt				
Jacket				
Short socks				
Long socks				
Tights/Legging				
Sandals				
Shoes				
Boots				
Scarf/shawl				
Hat/cap				
Other (please specify)				

Time : : : :

7. How would you describe your activity level in the 15 minutes prior to completing this survey?

Seated (passive, relaxed; e.g. reading)				
Seated (active, working; e.g. typing)				
Standing (passive, relaxed)				
Standing (active, working)				
Walking (indoors)				
Walking (outdoors)				
Other (please specify)				

8. If you ate or drank anything in the 15 minutes prior to completing this survey, what temperature was it at?

Cold				
Room Temperature				
Hot				

9. Please let us know about the following states of environmental controls in your office, close to your workplace: (please tick if appropriate)

Door open				
Window(s) open				
Blinds/curtains down				
Lights on				
Air condition on				
Room Heating/Heater on				
Fan on				
Other (please specify)				

10. Did you actively change any of the following? (Please circle or underline which applies)

Item of Clothing	on / off	on / off	on / off	on / off
Heating	up / down	up / down	up / down	up / down
Fan	up / down	up / down	up / down	up / down
Prototype	on / off	on / off	on / off	on / off
Window(s)	open / close	open / close	open / close	open / close

Time : : : :

11. If so, what was your reason for doing so?

I felt hot				
I felt warm				
I felt cool				
I felt cold				
Other (please specify)				

12. If you have any additional comments, please let us know:

Study Evaluation Questionnaire

In the following questionnaire we would like to hear about your use of our prototypes during the past two working days. We would like to know how satisfied and comfortable you were using them and if they made a difference to your thermal comfort.

Personal Cooling Prototype: Ambient Control

1. Did you use the prototype?

Yes (more than one day)

I started but stopped using it, because: _____

No

2. When and how often did you approximately use it? (Please let us know, for example, if there were specific times or occasions you used it. If you did not use it or started but stopped using it, please let us know why.)

3. Please describe any **advantages and benefits** of the prototype and of how it is controlled, which you encountered:

4. Please describe any **limitations and shortcomings** of the prototype and of how it is controlled, which you encountered:

5. Did the prototype interfere with your work? If so, please let us know in what way.

6. Did having the cooling prototype have an **impact on your feeling of control** over your local thermal environment? Please rate on a scale from 1 (very much decreased) to 7 (very much increased) my feeling of control over the local thermal environment.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very much decreased	Decreased	Slightly Decreased	No change	Slightly Increased	Increased	Very much increased

7. Did having the cooling prototype have an **impact on your perceived thermal comfort**? Please rate on a scale from 1 (very much decreased) to 7 (very much increased) my perceived thermal comfort.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very much decreased	Decreased	Slightly Decreased	No change	Slightly Increased	Increased	Very much increased

On a scale from **1 (very dissatisfied)** to **7 (very satisfied)**, please let us know how satisfied you were with the following aspects of the cooling prototype:

		Very Dissatisfied					Very Satisfied	
		1	2	3	4	5	6	7
Functionality and Control		-----						
8.	The amount of cooling it provided	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9.	The ambient temperature control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10.	Its effectiveness of providing thermal comfort	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Context Related		-----						
11.	The portability of the device	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12.	The ease of using the device in the context of your work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13.	The appropriateness of the device in your workplace ("feeling awkward")	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
User-Friendliness and Wearability		-----						
14.	The comfort of wear of the device	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15.	The unobtrusiveness of the device	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

On a scale from **1 (strongly disagree)** to **10 (strongly agree)**, please let us know how much you agree with the following statements:

		Strongly Disagree								Strongly Agree	
		1	2	3	4	5	6	7	8	9	10
16.	I feel self-conscious having people see me wear this device.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17.	I feel the device moving on my body.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18.	I feel some pain or discomfort wearing the device.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19.	I feel awkward or different wearing the device.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20.	I feel that the device affects the way I move.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21.	I feel secure wearing the device.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

22. Do you have any suggestions for alterations in regard to how the prototype works and how it is controlled? If so, please let us know.

Thank you very much for your participation!

Study Evaluation Questionnaire

In the following questionnaire we would like to hear about your use of our prototypes during the past two working days. We would like to know how satisfied and comfortable you were using them and if they made a difference to your thermal comfort.

Personal Cooling Prototype: Manual Control

1. Did you use the prototype?

Yes (more than one day)

I started but stopped using it, because: _____

No

2. When and how often did you approximately use it? (Please let us know, for example, if there were specific times or occasions you used it. If you did not use it or started but stopped using it, please let us know why.)

3. Please describe any **advantages and benefits of the prototype and of how it is controlled**, which you encountered:

4. Please describe any **limitations and shortcomings of the prototype and of how it is controlled**, which you encountered:

5. Did the prototype interfere with your work? If so, please let us know in what way.

6. Did having the cooling prototype have an **impact on your feeling of control** over your local thermal environment? Please rate on a scale from 1 (very much decreased) to 7 (very much increased) my feeling of control over the local thermal environment.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very much decreased	Decreased	Slightly Decreased	No change	Slightly Increased	Increased	Very much increased

7. Did having the cooling prototype have an **impact on your perceived thermal comfort**? Please rate on a scale from 1 (very much decreased) to 7 (very much increased) my perceived thermal comfort.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Very much decreased	Decreased	Slightly Decreased	No change	Slightly Increased	Increased	Very much increased

On a scale from **1 (very dissatisfied)** to **7 (very satisfied)**, please let us know how satisfied you were with the following aspects of the cooling prototype:

		Very Dissatisfied		3		4		5		6	Very Satisfied		7
	Functionality and Control												
8.	The amount of cooling it provided	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9.	The manual temperature control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10.	Its effectiveness of providing thermal comfort	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	Context Related												
11.	The portability of the device	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12.	The ease of using the device in the context of your work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13.	The appropriateness of the device in your workplace ("feeling awkward")	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	User-Friendliness and Wearability												
14.	The comfort of wear of the device	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15.	The unobtrusiveness of the device	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

On a scale from **1 (strongly disagree)** to **10 (strongly agree)**, please let us know how much you agree with the following statements:

		Strongly Disagree							Strongly Agree		
		1	2	3	4	5	6	7	8	9	10
16.	I feel self-conscious having people see me wear this device.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17.	I feel the device moving on my body.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18.	I feel some pain or discomfort wearing the device.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19.	I feel awkward or different wearing the device.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20.	I feel that the device affects the way I move.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21.	I feel secure wearing the device.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

22. Do you have any suggestions for alterations in regard to how the prototype works and how it is controlled? If so, please let us know.

Thank you very much for your participation!

E.3. Interview Transcriptions

Participant P1

Time	ID	Interview	Gestures
00:01	I	First of all, thank you very much again for testing my cooling prototype. I have several questions regarding your use and how you liked it and several aspects of it. I would like to start by asking you how did you use it or where did you place it?	Interviewer hands the cooling prototype to participant p1
00:26	P1	When you first gave it to me and when we tried it out I use it at the arm.	P1 hovers the prototype over her left upper arm, slightly above the elbow.
00:31		But I felt that it was a bit distracting with the cable, and I didn't know where to put it.	P1 holds the prototype with her right hand and slightly lifts the cable attached to it first, then the battery, which lies next to her.
00:39		During the study I use it at my lower leg and my calf. Yes, just put it around it and strapped it on, like this. I usually had this like this.	P1 puts the prototype around her left lower leg. She moves it back up onto her lap, unfastens the Velcro and puts it around her left lower leg, fastening it using the Velcro strap.
00:58		I placed the battery at the floor usually, so that was okay, and it didn't distract me.	P1 picks up the battery lying next to her and holds it next to her knee, gesturing with it towards the floor.
01:07	I	Okay.	P1 unstraps the prototype from around her calf.
01:11		The prototype featured two different control settings and when you could choose between them, which one did you choose?	P1 places the prototype on her left upper leg, holding it in place with her hands.
01:20	P1	I choose the ambient one. So, where it regulates the temperature on the temperature of the ambient environment	P1 gestures with her hands.
01:31		because I found out, or I perceived that it gets colder with that setting. So, that was...	P1 briefly picks up the prototype from her upper leg and puts it back down.
01:42	I	Okay.	
01:43	P1	When I switched, it got a bit colder. I don't know that really, but I felt it got a bit colder.	P1 gestures with her hands and briefly moves the prototype on her upper leg.
01:49	I	Okay, so you had it on the highest setting?	
01:53	P1	Yes, yes almost the highest setting.	P1 shifts her attention back to the prototype looking down on and slightly turning the control knob and showing it to the interviewer.
01:57	I	Okay, so it was mainly about the temperature.	
02:03	P1	Yes.	

Time	ID	Interview	Gestures
02:05	I	Okay.	
02:06	P1	So, when I tested the ambient thing, I really didn't experience that it changes when the ambient temperature changes. Because, yeah, there wasn't much of a temperature change, so I couldn't really experience it. So, it was mainly that it got a bit cooler.	P1 gestures with her hands, the prototype resting on her lap.
02:24	I	Thank you. So, how would you describe the difference between the two settings? Could you describe the difference? But you already kind of answered that.	
02:42	P1	Yeah. I didn't feel much of a difference except that it got a bit cooler.	
02:47	I	Okay. Otherwise do you have any comments or wishes regarding the control of the cooling device?	P1 is briefly picking up the prototype by two of its corners.
02:57	P1	So, I wouldn't. I really like this control because it is quite easy, you just change it.	P1 puts it down again, still holding one corner with the right hand and tipping on the control knob with her left index finger first, then making turning movements in mid-air.
03:04		And you can also do it whilst wearing it, so you don't have to put it off and change it and put it back on. It was quite easy.	P1 continues to gesture in mid-air, indicating how she would take off the device from the lower leg, turn the knob and put it back on.
03:13	I	Okay. Did having the device affect your comfort in anyway?	
03:22	P1	Well, it was a slight relief, but since I wore it on the lower leg, I would have wished for two devices to wear on each leg. I think that would have improved it a bit more, it would have a better cooling effect.	P1 briefly points towards her lower leg.
03:38		So, in general, it made me a bit more comfortable at the workplace when it is hot, but other than that?	
03:47		Maybe it would be interesting to make a smaller battery, not a smaller battery a smaller fan. Because sometimes it was sliding down a bit due to the weight and so I had to try to [inaudible] a bit to fix it in position so it doesn't slide down. That was a bit distracting because then I had to readjust things.	P1 looks down on the prototype, hovering with her hands over the fan. She indicates a sliding movement down her lower leg with both of her hands.
04:12	I	Yes.	
04:12	P1	But otherwise.	
04:14	I	Okay. In the questionnaire you mentioned that you did not use it on the fourth day because you co-worker was in.	
04:22	P1	Yes. [laughing]	
04:24	I	Could you elaborate?	

Time	ID	Interview	Gestures
04:25	P1	Yes, so on the fourth day I wasn't really in the mood to explain to her what this is. So, that was a bit hindering me to use it because I didn't want to make the noises. And she might have given me curious looks what it is. It was a bit awkward.	P1 is gesturing with her hands. She briefly points towards the prototype on her lap.
04:50	I	How was it during the past two days that you had it?	
04:57	P1	It was better. So, I didn't use it yesterday. I used it on Friday and Thursday and I used it Friday a bit when I was alone. Yeah.	
05:09	I	Okay. You also mentioned that you sometimes use a fan if you feel too warm...	
05:18	P1	Yes.	
05:18	I	... in the office but you do not like it when it is pointing towards you.	
05:22	P1	Yes.	
05:23	I	How does the prototype compare to using a fan?	
05:30	P1	Yes. I really don't like it pointing at me, so I use it to get a bit of an airflow in general through the office.	P1 simulates air flowing towards her face with her left hand first, then moves her hand in circles in front of her upper body.
05:42		So, I really like this device, yeah, that it is just for me. So, that is a contradiction or something, because yeah, I don't like to use a fan because when there are other people you have to, they may not like it. So, this is a personal device just for me.	P1 briefly puts her left hand on the prototype resting on her lap, then starts gesturing in mid-air.
06:05		So, that is better, but on the other hand, yeah, I do like to use a fan in the office for airflow, so this is contradictory. [laughs]	
06:16		But yes. I really like also that with this device it is not... So, you have it on your body, so you have an instant cooling effect, instead when you have really hot air and the fan is not really causing, it's not cooling down the air.	P1 hovers briefly with her hands over her legs, before continuing to gesture.
06:33		And this one has a cooling effect if you know what I mean.	P1 briefly touches the prototype.
06:37	I	Yes.	
06:37	P1	That is an advantage.	
06:40	I	Okay, yes. Do you have any other comments because I don't have any other questions?	
06:49	P1	Yes, for me another colour would be nice, not blue.	P1 picks up the prototype and looks at it, thinking.
06:55	I	Okay.	
06:56	P1	Yes, but other than that? It was quite okay to use.	
07:02	I	Okay, well thank you very much again. I am going to switch off.	

Participant P2

Time	ID	Interview	Gestures
00:01	I	First of all, thank you very much for agreeing to this meeting. I have some questions regarding the prototype and the control and the behaviour of it. If I give you the prototype, if I could ask you first how did you use the prototype and where did you place it on you?	Interviewer hands the prototype to p2, who puts it down on her lap.
00:24	P2	Three places. One is on my arm and my leg and just holding it in my hand because I usually sweat a lot when the weather got warm.	P2 briefly points towards her lower arm, upper leg and opens and closes her left hand.
00:36	I	Okay. Can I quickly ask you where around your arm and leg?	
00:47	P2	Here. So, close to the bend.	P2 places the prototype inside her left elbow.
00:50	I	Yeah.	
00:51	P2	And here.	P2 puts the prototype on her left upper leg, shortly above the knee.
00:53	I	Okay, thank you. Then the prototype featured two different control settings. One was manual and one was...	
01:04	P2	Yeah, I tried both of them.	
01:05	I	Yeah?	
01:06	P2	Actually, I read it in the questionnaire. So, when the weather is slightly warm, I prefer to let it adjust the temperature. However, when I feel really hot, I like to adjust it by myself to make it cooling, as fast as possible. [laugh]	P2 plays with the prototype on her lap.
01:25	I	[Laugh] Okay cool. Thank you. How would you describe the difference between the two settings?	
01:38	P2	The second mode [manual setting] I can feel the difference of the temperature immediately. In the first mode [ambient setting], maybe depends on the ambient temperature. So, it's not very obvious but I still feel. I think the prototype can still have enough cooling for me.	P2 gestures with her left hand while the right hand is resting on the prototype.
01:57	I	Okay. In one of the questionnaires you mentioned that the device helps you feel cool on the whole body level. But when you switched it off, when it was, I think, in the manual mode, you felt hot again.	
02:16	P2	Yeah.	
02:17	I	You mentioned that you'd prefer some automatic setting?	
02:22	P2	Yeah. Two points. The first point is if it can turn on for a little while and then turn off. Then it depends on the ambient temperature, if it is still very warm it will automatically turn off.	P2 gestures with both her hands in mid-air.
02:41		The second point is as soon as I put it on my arms for maybe a few minutes then it's still cooling but	P2 puts her right hand briefly on the elbow-bent of her left arm.

Time	ID	Interview	Gestures
		I can't feel it any more. So, like this, I just turn it to the other part of the arm. I can feel it again.	She then takes up the prototype and puts it with the cooling are on the bent and then slightly moves it to the left.
03:02		That's why when I'm wearing this, I tend to use the hand to adjust the place and the same happened when I'm wearing it on my leg.	P2 puts the prototype back down on her lap and then moves her right hand around her left lower arm.
03:13	I	Okay. What kind of behaviour would you want the device to show in these cases?	
03:26	P2	Maybe all of this part could be cooling together.	P2 picks up the prototype from her lap and flips it around. She runs her right hand across the whole of the prototype's back side.
03:33	I	Okay. I actually have a question on that as well, because when you say... I understand that you'd prefer to be like all the way around...	
03:52	P2	Mm-mm. I think I'll adjust it this way is a bit difficult than adjust it this way.	P2 indicates with her right hand adjusting the position of the prototype on her left arm, first around her arm and then up and down her arm.
04:02	I	Okay, yeah. How does that work out when you are working? Because I assume you wore it while you were working?	
04:12	P2	Yeah. Just using hands to adjust it.	P2 again makes a movement around her left arm with her right hand.
04:17	I	Okay, so how often did you do it?	
04:21	P2	I did not count the time. But when I think it's no longer cooling, it is cooling but because I read about the paper about the... I forgot how to say that word but so, the tactile feeling, well, used to the... adjust it to the situation...	P2 gestures with her hands in mid-air.
04:50	I	Yeah.	
04:51	P2	...so, if you press something for some time, it no longer feels you are pressing it. So, I think, the same principle of the cooling device. When it's cooling on my part of the skin, at first, I can feel it, but for some time, sometime later so maybe it's not so obvious.	P2 points towards the prototype on her lap. P2 points to her lower left arm.
05:11	I	Okay, so you changed it whenever you couldn't feel it?	
06:13	P2	Yes. Just the turning or move it a little bit.	P2 puts her right hand over her left elbow bent and makes a turning movement around the arm as well as up and down the arm.
05:19	I	Okay, now I get it. Thank you very much. Do you have any other comments or wishes regarding control or behaviour of the cooling device?	

Time	ID	Interview	Gestures
05:36	P2	The behaviour. Hmm. [pause] I think that's all.	P2 picks up the prototype at both ends.
05:45	I	Okay. One more...	
05:53	P2	Ah yeah, it reminds me. So, the first two days, I wearing the long sock stockings...	P2 gestures with both of her hands in mid-air.
06:01	I	Okay, yeah.	
06:02	P2	...so, when I put it on my leg it just I think it's nothing to do with the prototype but this... how you say this attachment?	P2 picks up the Velcro strap of the prototype.
06:12	I	Velcro.	
06:13	P2	Velcro, um...	
06:19	I	It got stuck on there and tore it? Or...	
06:20	P2	Yeah, got stuck.	
06:24	P2	It just attached to my stockings and just pulling it, and the stocking is ruined [laugh].	P2 indicates up and down her right leg.
06:33	I	Oh no, I'm really sorry about that. Okay.	
06:37	P2	That happens.	
06:40	I	Yeah, I understand it's tricky with these things.	
06:45	P2	Then I think maybe the female and the male have different requirement regarding to the where of the device is.	
06:53	I	Yeah, definitely. No, it's true. Can I ask one more question? What do you usually use for cooling? Like, a fan, or how do you usually cool?	
07:14	P2	We do have two fans in our office. But the one went to the other office and no one knows the people in the other office, so only one fan left now. But usually the people, the aging people in my office, they object to the fan because maybe they are more sensitive to the temperature. So, I only using my manual fan, the folding fan, to cooling myself.	P2 gestures in mid-air.
07:50	I	Yeah. How does this compare to your folding fan or an electric one?	
07:56	P2	This one's good. Because it generally cools by itself. But the folding fan, I use my arm with my left hand so when I'm cooling myself I can't have... I can't write. That's the problem. But this one I can wearing it on my arms, or legs, so it won't interfere with my work.	P2 points towards the prototype.
08:20	I	Okay.	
08:23	P2	So that is the advantage!	
08:25	I	[Laugh] Okay, thank you. Do you have any other comments or suggestions?	
08:39	P2	Actually, I'm thinking. This one you build this one, so the purpose is a wearable? Is that right?	
08:50	I	The purpose...	
08:52	P2	The purpose of this prototype is making it a wearable?	
08:56	I	Yeah.	

Time	ID	Interview	Gestures
08:57	P2	Oh, I see. So sometimes when I feel hot I prefer to leave it on the table like this. I put it on here and then just to hold on this.	P2 picks up the prototype with the cooling element up and looks around for a place to put it. She finally puts it on the table in front of her. She places her hand briefly on the cooling element.
09:13	I	Okay. So, you used it more like something just available in the environment?	
09:19	P2	Yeah, you put it on the table and touch it! [laugh]	
09:22	I	Okay, that's cool as well, that's interesting to hear actually. Okay.	
09:33	P2	If I were to wear it, if it's wearable and if I wanted just to touch it then it can stand on the table by itself. I think it'd be really cool.	
09:46	I	Okay, thank you very much.	
09:49	P2	No problem.	
09:50	I	That's a great help.	

Participant P3

Time	ID	Interview	Gestures
00:01	I	First of all, thank you very much for testing my prototype [slight laugh]...	
00:03	P3	No worries.	
00:05	I	...and I have some questions regarding the use and what you thought about the controller. First, about the use maybe. How did you use the prototype and where did you place it?	Interview hands the prototype to P3.
00:22	P3	Well, first, I was just keeping it in my lap.	P3 puts the prototype on his left upper leg.
00:27		But then I felt a bit uncomfortable because it was too cold, so I was just keeping it on the table next to the keyboard.	P3 picks the prototype up with his right hand and holds it in mid-air with his left hand, slightly moving it to his left side.
00:36	I	Okay.	
00:37	P3	So, I've been using it for the rest of the experiment.	P3 holds the prototype in both hands in front of him.
00:44	I	Okay. How did it cool when you had it next to the keyboard?	
00:52	P3	It was just blowing the air. It was a kind of similar as a ventilator.	P3 holds up the prototype with his left hand and moves his right index finger to and for between the prototype and his upper body.
00:57		and sometimes I was putting the hand like that. Some of the time but not that often.	P3 puts his right hand briefly onto the fan, removes it and puts it on top again briefly. Then he takes the prototype between both hands.

Time	ID	Interview	Gestures
01:03		So yeah, just to have some air moving.	P3 gesticulates with his right hand, circling it in front of his body.
01:07	I	Okay. Thank you. The prototype features different control settings, like a manual and ambient control...	P3 takes the prototype between both hands and looks at it, turning it.
01:18	P3	Yeah.	
01:18	I	...which one did you choose when you could choose?	
01:22	P3	I tried to try both of them, but I didn't really see much difference.	
01:30		I'm not sure maybe the temperature didn't change that much, so it was just... I wouldn't be able to distinguish the difference.	P3 describes a sine curve in mid-air with his right index finger.
01:39	I	Okay. Could you describe the difference in some way?	
01:48	P3	No, not really.	
01:49	I	Okay. In the questionnaire you mentioned that it would be nice to have a wider control range, like [over speaking]?	P3 holds the prototype in his left hand and gathers the cable with his right hand putting it into his left.
02:04	P3	Yeah, yeah. It would be nice if I could make it less powerful, then maybe I could keep it on my body.	
02:13		Then I might also be able to see the difference between the ambient and non-ambient versions.	P3 looks down at the prototype and plays with the fan with his right hand.
02:20	I	Okay. Would you have any other comments or any wishes regarding control or behaviour of the cooling device?	P3 looks down on the prototype.
02:34	P3	Yeah, maybe having a wider area, of the cooling area, would be nice.	P3 moves his hands apart in front of his body. Then he looks down on the prototype in his left hand and starts playing with the fan with his right hand.
02:44		Apart from that it is alright. Well, it would be nice to have it lighter.	
02:51	I	Lighter?	
02:52	P3	Yeah. But it is a prototype, so it's okay.	
02:56	I	Thank you. How does having the device affect your comfort or did it affect you...?	
03:05	P3	I think it was helpful, especially today I was using it. But then the battery died so I couldn't. So, yeah it definitely had a positive outcome.	P3 keeps playing with the prototype in his hands.
03:21	I	In the questionnaire you also mentioned that you got used to the device quite quickly?	
03:32	P3	Yeah.	
03:33	I	Were there any issues, at first or...?	
03:41	P3	No, I think towards the end I had to charge it, because the battery went off. But then I was forgetting it, so I had to put it on. Or maybe it	P3 gestures with his hands, holding the prototype in his left hand.

Time	ID	Interview	Gestures
		was charging and then I wasn't using it, so yeah, just the battery was a bit complex.	
04:02	I	Okay. You also mentioned that you felt pain?	
04:05	P3	Yeah, because it was just too much.	P3 moves his right hand quickly up and down.
04:08	I	Okay.	
04:09	P3	Yeah.	
04:12	I	Then one more thing, in the questionnaire you mentioned, like in the general comfort questionnaire, that you usually drink cold water if you feel too warm?	
04:24	P3	Yeah.	
04:26	I	And I think that was the only thing you actually do. How did the cooling prototype compare to this, like in reflection, making you happy, making you feel comfortable?	
04:47	P3	Well, I think I was still drinking lots of water [laugh]. But on the other side for water I need to go downstairs and get, interrupt everything I'm working on but with this thing you just turn it on, so it's much less intrusive I would say to the workflow, which is a positive thing.	P3 gesticulates with both hands. He makes a turning gesture with the fingers of his right hand while hovering over the prototype in his left hand.
05:06	I	Okay. Also do you use a fan every now and then, or?	
05:12	P3	I used to use a fan. But honestly, I'm not a big fan of them! [laugh] Because they make draft and then all the papers scatter around the office.	P3 plays distractedly with the fan on the prototype. He starts gesturing with his hands circling his right hand.
05:26	I	Okay. Do you have any other comments?	P3 looks down at the prototype.
05:33	P3	I think it's a great device. I enjoyed using it.	
05:38	I	Thank you very much.	
05:40	P3	Welcome.	

Participant P4

ID Interview

I First of all, thank you very much for participating in testing the prototype.

P4 That's alright.

I I have a few questions regarding your use and experience with it. The first one is how did you use the prototype, where did you place it?

P4 Physically?

I Yeah, physically?

P4 I started on my upper arm, because that instinctively maybe 'cause it looks like the blood pressure things [slight laugh]? I thought that was where I wanted it, straight away, no question. But actually, that didn't last long, for a couple of reasons because it was straight onto my skin, so it actually got really, really cold. Then also because it *[inaudible 00:49] [background noise] did tug a little bit, with the wire. So, then I moved it down to my thigh.

I Okay, yes. Thank you.

ID Interview

P4 Once I'd moved it that was where it stayed, that's when I...

I Okay.

P4 ...all the other studies I always put it there.

I Okay that's good to know, thank you. The prototype features two different control settings. During the last two days, you were able to choose, so which one did you set it to?

P4 I just used the manual one.

I Okay. Without ambient?

P4 Yeah, it just seemed more, I don't know I felt like I was in control a bit more. I think with the first, with the ambient control I was almost double guessing it, and then I fiddled with it when I shouldn't have fiddled with it. Then I was like 'oh I don't know where it is now' 'cause I felt like the first time I set it I think I set it too cold maybe? Then I knew I had to leave it alone and let it regulate itself, but I was still going, 'ooh it's too much' and it was on my arm. So, I just used manual control 'cause I knew it was much more...

I Okay. Thank you. How would you describe the difference between the two settings? You already...

P4 Yeah, I felt like with the ambient setting that I was committed 'cause it was locked into my choice first thing in the morning. Then I'd doubt it and it was, 'oh no it's not right na-na-nah' so it was just it was more I felt 'oh it's okay to change because it's that normal control, I don't need to think I'm working against the system I'm just turning it when I need to turn it. I don't need to think.

I Okay.

P4 I know you don't have to think with the ambient but... does that make sense?

I I think yeah.

P4 Yeah.

I Do you have any other comments regarding the control, any issues in regard to the control and behaviour of the device?

P4 My obvious things about it are the fact it's a prototype, so the fact it's got the fan making the noise more than anything. And the battery with the cable, so every now and again I'd stand up and wrench the cable, wrench the battery out or something. That's obviously 'cause it's at the stage it is. I realised I hadn't really paid attention and then I had to work out which way was colder, 'cause I don't know if that's me being really simple, but I wasn't sure if 'low' was less cold, that looks like more cold? Or is that cold *[inaudible 04:13] with the smallest. Because you're trying to increase something that is a negative. Anyway, I spent a little while playing to work out actually what was up, what was down. What does 'up' mean? If it's concerning the cold? [laugh]

I Yeah, true [laugh]. One more question. What do you usually use when you're too hot, what do you use for cooling? How would you say the prototype compared to that?

P4 Honestly, it depends who is in the office. If I'm there by myself, I'll open all the windows and I'll jam open the door. But because there's other people there I will tend to not do very much, just sit and bear it. I like it, I liked it a lot. I find it much easier to deal with being cold than being too hot. Being too hot affects me working much more, I find it really distracting and it mucks up my concentration. So, it was nice to be able to have that. Again, the other option is to turn a fan on, but I feel very self-conscious about that because it's a fan, it's not localised. If nothing else, temperature aside it can be really annoying 'cause you're just blowing people's papers around and stuff, I don't really feel... I never ever put a fan on unless I'm the only person there.

I Okay. Thank you.

P4 I did unblock the vent in the ceiling, but 'cause I thought I'd blocked it up when it was winter, and it was on. I saw the air was coming out and I thought 'ah maybe they've turned it back on for the summer which would be logical'. So, I took it out but realised it was not actually turned on, it's just draught!

I Ah okay, yeah. Do you have any additional comments anything you'd like to...?

ID Interview

P4 No, I don't think, not particularly. Could do with a slightly longer strap once I've got it on my thigh.

I Okay, yeah.

P4 But, I liked it. Oh I thought when I had it, sometimes it was really hot last week, so I was 'oh just crank it up' but that there I found actually when it was really turned up, down, it was too localised and it was uncomfortable 'cause it was like something really cold pressing against you. So, if it were dispersed more, spread out round the back instead of on that, then I'd like that a lot more.

I Okay thank you very much, that's all the questions I had, thank you again.

P4 That's alright.

Participant P5

Transcription from memory (camera did not record parts of the interview):

Q1: How did you use the prototype? Where did you place it?

P5: At first, I had it on my arm [indicates to right upper arm] but that did not feel comfortable when I was working and typing. So, I then moved it to my leg [points towards mid upper leg] and put it around my leg.

Q2: The prototype featured two different control settings. Which one did you choose when you could choose?

P5: To be honest, I did not select any. I just left it at the last setting you set because that worked for me. I did not feel like changing it.

I: I think that must have been the ambient setting, when the prototype adapted to the environment and ambient temperature.

P5: Yes, that might be.

Q3: How would you describe the difference between the two control settings?

P5: I think one of them got cooler than the other, but I don't know which one that was. I also could feel the cooling effect more continuously with one of the settings. But I don't know if that was the last one I used.

[transcription starts from video]

P5: So, what was I saying.

I: So, one was constantly cooling.

P5: Yeah for the other one it's like after a few whiles, I didn't, I can't feel anything. So, I think one of them is better. Yeah, yeah. I like the one constantly cooling me, yeah, yeah.

I: Okay, cool. Um, do you have any comments or any wishes regarding the control or the behaviour of the device?

P5: The control, um, I guess, if it's easier to switch between the modes, I would try to do it. But because now at this moment, um [reaching for prototype]

[transcription from memory because video stopped]

P5: You have to open it and reach inside. If the switch was easier accessible from the outside, I would have maybe used it.

[transcription from video]

I: If we could start again with the question

P5: Okay.

I: So, in the daily right now questionnaire you mentioned that the fabric of the prototype made you feel hot

P5: Yeah

I: and you could not feel the cool anymore

P5: Yeah

I: so, you took it off

P5: yeah

I: So, did you do any other form of adjustment

P5: You mean on the prototype?

I: Like turning it. Yeah sorry, it's not working. No, it is still recording, so.

P5: Um

I: Like turning it or putting it somewhere else on your body.

P5: I think I... um, you mean on the hand, the first. Oh, you mean I feel.

I: Yeah, when it was warm on one part, did you put it somewhere else?

P5: Yeah, I tried. Like, uh, first day on the hand. I feel it's not like, uh, uh, very comfortable and also hot. So, I, I tried, uh, on here but it doesn't work very well so I didn't put it on and then I tried my leg and then I find it's good. So, I put it on there.

Participant P6

ID Interview

I First of all, thank you so much for participating in the study and for testing the prototype. I'll give this to you...

P6 Yeah.

I ...because I have some questions on how you used it. The first one would be how did you use the prototype, so where did you put it?

P6 Yeah. I put it mostly on my left arm and I would put it up the top, up here. Mostly because that was where it was most out the way, 'cause I do a lot of typing and writing with my right hand. I had it on my wrist a couple of times, but I found it was a little restrictive when it comes to typing and doing things, I put it higher up.

I Yes, okay, thank you. The prototype featured two different control settings. When you could choose between them, which one did you choose?

P6 I went for the ambient most of the time. I started with the manual but then I changed to the ambient. Because giving it the control is less for me to do. That's why I chose ambient.

I Okay, yeah. How would you describe the difference between the two settings?

P6 Ambient felt more natural, when you had manual and put it right up to the top it felt almost too cold. But with ambient it was never too cold, but it stayed at a nice cool temperature. I didn't really have to move this at all, so it was really easy to use, over the manual. [s.l. brilliant 01:55].

I Okay, thank you. Do you have any comments or issues regarding the control or the behaviour of the device?

P6 No, I kept it on ambient the whole time and I didn't really incur any issues.

I Okay. You mentioned in the questionnaire that the prototype didn't fit properly around your arm and I was wondering if you had any suggestions how this could be improved?

ID Interview

- P6 I'm not sure, it's just because when I put it on I have really thin arms and I didn't have the contact the whole time because it was difficult to put it round like that. Hmm it's a tricky question, if it's going to be used for other people as well, it's finding the compromise of how. But if it was a device just for me then obviously I could have it made to the size of my arm, so I guess it depends on what the device is for, if it's for sharing or a personal device?
- I Okay, yeah. Thank you. In the comfort questionnaire the one in the beginning, you mentioned you would wish for your own fan cooling device to have more personal control? Regarding the cooling device, did you have anything specific in mind? Or is it more general?
- P6 I think something like this it did really help especially on the hot days like this, something like this is probably better than a fan because it's not affecting others, but it's just personal to me. But it's mostly because of where I'm placed in the room as to why I said a fan, because I'm in a corner so there's literally no air movement there. If I had a fan on me it wouldn't really affect everybody else. If I was in the middle of the room, then maybe a more discreet device like this would be better. But yeah it worked really well.
- I Okay, thank you very much. How does this prototype compare to, for example, personal fan but I think you already answered?
- P6 Yeah, it's more discreet and I don't have to worry about other people around me and upsetting them, which is always an issue in a shared space. Nice and discreet.
- I Okay, thank you. Do you have any additional comments or suggestions or anything you would like to say?
- P6 No [laugh].
- I That's fine. I just wanted to give you the space. Okay, thank you. That's all.

Participant P7

ID Interview

- I First of all, thank you very much for participating and for testing the cooling device and I have several questions on how you used it and what you thought about it. First question would be how did you use the prototype, where did you place it?
- P7 It was placed on my forearms here. I felt it more comfortable because putting it on any other part of the body didn't seem plausible.
- I Okay.
- P7 When I was discussing with you, I think you showed me around, but you were touching my forearms and I didn't think any better place apart from that. I felt the forearm was the right one.
- I Okay. Just for me to understand, which way was the cooling area facing?
- P7 It was on the top.
- I On the top of your arm. Okay. The prototype featured two different control settings or modes?
- P7 The ambient one and the non-ambient one. The last of these was the ambient one where we switched it.
- I Yeah, so during the last two days you could actually choose between them?
- P7 It was the automatic, I think it was the temperature.
- I Yeah, yeah so that's the setting you had it on. Okay. How would you describe the difference between the two settings?
- P7 I didn't find major differences to be honest, because I think out here the last few days since when I started it was a lot more pleasant out here. While initially when I started it was a bit warm. So, I didn't find any difference in general, it's going to be a bit unfair to compare them over time or something. But maybe if it was extreme hot versus the first when we initially started playing with the prototype it was quite warm, it was one of the hottest weeks of September and summer. I felt the prototype was very useful that time. But over time and as time progressed I think the weather in general started becoming

ID Interview

more pleasant and it's more adjustable. So, it was not that very hard to adjust in general. That's the only difference I found out. But yes, I didn't find any major differences moving between the automatic control versus the one where we didn't have to switch it on and make it automatic as we might call it, yeah. I couldn't find major differences.

I Okay, thank you. Do you have any other comments or wishes regarding the control or the behaviour of the device?

P7 Not in terms of behaviour of the device but a few parting comments would be that if the device could be made smaller, which I think I pointed out. The fan is a wonderful thing, but again in general that means it has to be in such a way that a novice has to be with some material more specific things regarding material where you need to be having certain material which can probably have a better control than just having this device out there. Because the heat from the body typically can be passed through the fan, but this fan is quite huge because the device is quite huge. Something where it's much smaller is a much better, easier one for us to work on the larger ones. That's the only comment I would put, and I think I already pointed that out to you in the questionnaire and other things.

[Interruption]

I I was going to pick up on exactly that comment in my next question, you already answered that.

P7 Oh okay.

I Brilliant. You mentioned in the questionnaire that the device, you've already addressed this as well, the prototype made you feel cooler...

P7 Yes.

I ...when you were warm, and it also made you feel comfortable and relaxed...

P7 Yes.

I ...can you elaborate on that?

P7 Typically, what happens is when it's very warm out here, and I'm talking about a month back when it was very warm actually, it was in such a way that we were finding it very uncomfortable because even the fans were not helping us. So that then the device, I don't know did it have a very relaxing effect, something which would only be probably get it from... it seems to be, I don't know if this is something natural or is it like you could feel very nice relaxed feeling around that area which moved to the whole arm and I was like, 'Wow this is a very wonderful'. Something which made me feel like having a massage or spa. I'm probably giving a very grandeur view of this, but it made me feel quite in that effect that I wish this could be replicated in other parts of the body, so I can be more feel at ease with myself. So that way I meant it was very relaxing in general and of course cool because you could also feel the hint of the fan when it was operating, you could probably it was double the fan because it was fanned from one end of this room and the other end was on my hand. So, I could feel that more effecting me quite quick. I was very comforted and feeling very relaxed then compared to feeling very warm and sweating in that manner. So, I felt the device really, really helped me out with that and I think if it could be something if it could be done for the whole room or something or something like a blanket [slight laugh] or something, it would have been amazing. But keeping those things aside I think it had this effect where you could feel very relaxed in terms of, it's something which unfortunately cannot be expressed in terms of how you feel. I mean I felt relaxed and I felt cool also, which was because of probably the fan or the other thing. The only thing that it was a bit clunky, it was big. If it was something where... I don't know how true it is, but the device had something like a part of a thing which was almost as small as a watch, maybe I don't know if the belt needed to be that big which you have right now, the bit of the belt needs to be that big? Because you could actually feel the cooling effect localised to a certain area and then suddenly it started going more global or moving towards to probably an area of your hand. That way I felt maybe the device could have been probably made a bit smaller, just localising into that part of the forearm and then probably moving around that same area. That's what my personal feeling is, which is why I wrote in the comments that maybe be the belt need not be that big or yeah.

That way I felt the device was perfectly as a very relaxing material. I'm sure that there are so many things around where people wear it as a belt, a magnetic belt or something which makes them feel cool, warm, as well as relaxed. I felt this device had a similar effect which is it made you feel relaxed. I don't

ID Interview

- know if it was a magnetic effect or something going on. But maybe it was there or not there we don't know but it had that effect and that was wonderful.
- I Okay, thank you. That's good to hear. Next question would be, because you've already mentioned that you also have this additional fan and that had been help during the hot period *[inaudible 08:06].
- P7 Yeah, yeah.
- I Because the question I always ask is, how did the cooling prototype compare to something like a fan, because of the different kind of, like it's cooling *[inaudible 08:30]...
- P7 Both of them helped. I cannot say that I wouldn't probably be doing one thing as like switching on the fan and seeing that fan would make anything. Because what would happen is only one part of the body would be feeling quite good. Maybe the effect of both the fan and the cooling prototype actually helped because I felt a lot more relaxed. It will be unfair to compare one against the other.
- I Okay.
- P7 My personal feeling would be both of them helped *[inaudible 09:07] I know it would be very unfair to judge one against the other. It's like judging between two fans. I think both of them helped.
- I Yeah, thank you. The last question is if you have any additional comments or suggestions?
- P7 The only suggestion would be to look into making it a bit smaller that would be the only suggestion. That would be the best suggestion, the best design probably and everyone will probably end up buying it and maybe it might become a product and not a prototype anymore. The one more thing which I felt was a bit uncomfortable was also like wearing it because there was a huge fan and the belt is an awkward type, not uncomfortable but I just didn't know how to put it. I'm not sure if the fan could be made smaller, for example looking at this, you have this fan out here so what we had to do was take the... what do you call this thing, sticker?
- I It's Velcro, material called Velcro.
- P7 Yeah so, this Velcro was not getting quite across and so strapping it was a bit hard. So, something where... in general I think that the material all where the fan was placed, and everything was wonderful. But it's just that the way that we could attach it was a bit hard. That's the only thing, I think this device was wonderful and in general was very helpful. A wonderful prototype in general.
- I Okay, thank you very much. That's all the questions I had and thanks again for participating.

Participant P8

ID Interview

- I *First of all, thank you very much for testing the prototype and participating in the study.*
- P8 You're welcome.
- I *I have several questions on how you used it and what you thought about it. The first one is how did you use the prototype, so where did you place it?*
- P8 I tried a few different options. The first one I tried was in different places on the arm. I was wearing a T-shirt at the time with short sleeves, which means the [inaudible 00:00:30] was directly on the skin. I found at the time that it was quite aggressive in terms of cooling down, as in I could recall on one square patch, even with the very lowest setting. Then I tried different places, you know on some days when it wasn't that hot, maybe I had long sleeves so I could do the same. It's more comfortable that way I find. I tried it on the legs as well, it's a bit more bulky so it can handle more cooling down, and I found it to work a bit better. Also, it doesn't prevent me from moving. That's mainly how I used it.
- I *Okay. Yes, okay thank you and then the prototype feature, two different control settings or remotes, so which one did you choose when you could choose?*
- P8 I chose the one with the feedback loop, the one that's measuring temperature and giving me the gradient, because why did I do that? Because on the first two days, it was this one and I didn't have a choice for the first two days, and then the two next days I had the other option, and I felt

ID Interview

more comfortable the two first days. I didn't think at all more than that. I was like, "Oh that's just when I felt more comfortable" So I'm just going to use this one.

I *Okay, yeah, I know.*

P8 Although it doesn't make a huge difference, because at the end of the day you are controlling the temperature here. It's just that you are not controlling the reference point. You're just turning until you are comfortable anyway, but I think it kind of makes sense to have it relative to the ambient temperature.

I *Okay, yeah so how would you describe the difference between the two settings?*

P8 I would say with respect to the ambient temperature, it tends to be more intuitive and a bit less aggressive as well, because when it's not it's basically transferring a given amount of heat that you don't really...It's not necessarily that meaningful because you turn it, it's going to be very cold and then it's freezing in here and I don't know... Whereas the other one was a bit more progressive in the way I was controlling the cooling down as well. I don't know. I don't have very good answers I'm sorry, but you just felt a bit more comfortable.

I *Okay, that's fine.*

P8 So that's my main...the main wedge of it.

I *Okay brilliant, thank you. No that's perfectly fine. I'm just curious to hear what people say and how they would describe it from their point of view.*

P8 Yeah, it felt a bit more...

I *There is no right or wrong.*

P8 It felt a bit more brutal when it wasn't relevant to the ambient temperature.

I *Okay cool.*

P8 Which could be good for some people, but it wasn't for me.

I *Okay thank you. Do you have any other comments, or do you have any wishes regarding the control or the behaviour of the device?*

P8 No, I think the controls were fine. Maybe one comment I can make is that I'm probably not the best judge for the device, because I don't know if you've looked at my feedback sheet, but basically the one thing I was complaining about was the room being stuffy, and the lack of air movement. I'm generally happy with the temperature in the room, so I'm not in desperate need for cooling, I'm in desperate need for fresh air, which that thing can't bring, it can't provide fresh air. One more comment I can make is that this is a...I like the idea of having your personal theme, and it's a very localised patch of coolness if I can say so.

When you're hot, you're hot everywhere usually, you're not just hot somewhere and having a small patch sometimes it's actually quite disturbing, because you're really hot and you have that patch somewhere which is freezing after a while, so it's kind of weird. I don't really know what to think about it. I didn't mention that, I forgot but when I was using it bare skin, I mentioned it earlier I think yeah, because the wind is blowing in the same direction as you are if you are wearing it like that, then you get really cold, because you've got the cooling underneath, plus the wind blowing that way. It's quite a lot of cooling.

I *Okay, yeah actually that would have been my next question because you mentioned it in one of your questionnaires that the fan blowing affected the [inaudible 00:05:39] feel cooler than the actual [inaudible 00:05:40] device...*

P8 Yeah, because it affects a bigger region effectively.

I *Okay I didn't know these things, but did you try to adapt in any way, like moving the device to other places or...*

P8 Yeah and actually I did that to take advantage of the wind, surprisingly, so when I noticed it was very windy I was like, "Yeah." One day it was really hot, I couldn't remember which day it was but there was one day it was really quite hot, so I put it on my lap. I would have the [inaudible 00:06:15] for the lap, but the thing is I just turned it in a way that it would blow down the leg, so that it would cool down the entire leg, instead of just that zone. It worked out pretty well actually, interestingly.

ID Interview

I *Okay that's good to hear.*

P8 It only works if you're using a mild setting in terms of cooling, because otherwise the radiator gets really hot, and in that case the wind being blown is really warm as well and it's kind of defeating the purpose, but if you use a mild setting it can work.

I *Okay thank you very much. The question was about the localised cooling and that it didn't feel comfortable. Would you have any suggestions for solving this problem?*

P8 Solving the localised cooling?

I *Yeah.*

P8 Now that's a tough one. I guess if you wanted to be really ambitious you could have an e-textile approach to it, which means you are having an entire shirt that you could wear that would cool you down everywhere. That would make some sense, I don't know how practically feasible that is, it's probably very expensive to get one, but that would make more sense to me, because the localised thing is good as a proof of concept, but I don't think it can scale, because when you're hot, you're not just hot there. So yeah, I think that would probably be one approach to it or having several patches in several key locations. That's the second thing as well, depending on where you put it you're not sensitive in the same way everywhere. I didn't use it on my neck because that's a very sensitive point and I'm pretty sure it would be too much. It would probably be good to have controls for several points in certain places, probably would be interesting. I would say yeah, either delocalizing or multiple locations would be probably something interesting, especially in a very hot environment like for people who are driving a lot and stuff like that it could be [inaudible 00:08:45]. Yeah, I'd be willing to try it actually, see how it works.

I *Okay, thank you and I've got one more question. So how did the prototype compare to using a fan or opening a window?*

P8 I don't know I don't have any fan, but it depends on what you're after really, but I thought about maybe playing something I forgot. Gee I lost track of what I wanted to say. So how does it compare? I don't know. It's a bit unfair to compare that to a fan I think, because a fan provides air movement which is a very different thing as, because you are basically...it's a bulk, mass cooling device, whereas the other one...another way to phrase it if you phrase it in terms of physics, this one works with conduction, whereas the other one is convection, which is very different and it feels very different, so I think the comparison is a bit unfair. I don't really like fans either. I like when there is air movement, but natural air movement, because usually fans I find it's a bit too much and I get tired of it after a while. Same as aircon, I don't like aircon because it really makes me sick all the time. I much prefer opening windows and having the air moving, that's what I tend to prefer, but if you come back to me with a nice shirt that can cool me...Why not?

I *Okay, yeah thank you very much, so do you have any other comments or suggestions? Otherwise I don't have any other questions.*

P8 No, I think that's pretty much it. Then it's about practical things, because the whole thing is quite heavy, and except the wind blowing in that direction that's the only one. It's small details, but definitely yeah, I'm looking forward to the jacket.

I *Okay well thank you.*

P8 You're welcome.

I *Thanks again.*

Participant P9

ID Interview

I First of all, thank you very much for participating in the study and testing the prototype. I have some questions on how you used it and what you thought about it. The first one would be, how did you use the prototype and where did you place it?

ID Interview

- P9 On my arm. At the beginning I used it as instructed, I *[inaudible 00:23] does. So, it was my lower arm. But in the end, I just found it quite cold, because I can only feel in this local area and it feels slightly like putting an ice cube on it, it's a little too cold. So, I put it on my and just put it next to me and I still turn on this thing, just use it to cool down the area around me and also 'cause here there is a small vent and that also creates some airflow for me as well.
- I Okay. To follow up, which way did you place it, with the fan up or down?
- P9 Like this with the fan up.
- I Okay, so the fan would cool you...
- P9 Yeah, yeah.
- I ...okay, thank you. The prototype feature two different control settings or modes, which one would you choose when you had the possibility to choose?
- P9 When I had the possibility, I chose the automatic one just let itself adjust to the temperature.
- I Okay, thank you. How would you describe the difference between the two settings? You mentioned in one of the questionnaires that you didn't actually notice?
- P9 I didn't really tell the difference, because *[inaudible 01:58] using is I adjusted it to be to the position where I felt most comfortable. When I left it, I didn't pay too much attention, I hardly feel *[inaudible 02:16] different.
- I Okay, what made you decide to leave it on the automatic setting then?
- P9 Such that I don't have to [slight laugh] *[inaudible 02:26] for convenience. I think it works quite well, so I don't have to do anything extra.
- I Okay, thank you. Do you have any comments or issues regarding the control or behaviour of the device in general?
- P9 Not really, I think it's very convenient, it's easy to use.
- I Okay, thank you. In one of the questionnaires you mentioned that the cooling device, you already mentioned actually in the beginning the device would only cool locally and not your whole body basically? What effect does this have, how did you feel, and do you have any suggestions how this problem could be solved?
- P9 Maybe that's just me, maybe other people find the other way, but I feel I prefer to having more uniform of temperature or a sensation. When I'm wearing this... for me I feel if I just feel cool locally it doesn't change much, it just creates some contrast in a feeling of *[inaudible 03:56] temperature. Not super comfortable, or... just doesn't solve the high temperature problem for me *[inaudible 04:08]. So, I *[inaudible 04:12]... but maybe what I suggest doesn't *[inaudible 04:15] into the purpose of your experiment. Just for the cooling purpose probably something which has a larger coverage of my body like a jacket or just a better thing with more... so I feel the same everywhere – it's less strong, it's not *[inaudible 04:42] it's just more average or it's something like I used externally like a fan, something I don't put directly to me, I don't apply but I put it next to me.
- I Okay. That's my next question! Because you also mention in one of the questionnaires that you usually switch on the fan for cooling. How would a device that's on your body compare to something that's more off your body? Would you prefer airflow?
- P9 Yeah, I'd prefer something that's off my body.
- I Okay, if you think about something like you said before, a jacket...
- P9 Yeah.
- I ...you'd still prefer not having that?
- P9 Directly, yeah.
- I Okay. That's more or less it. The last question I have is do you have any additional comments or suggestions?
- P9 I can't think of any. I think this is an awesome idea and it does solve some real, practical problems that we're all facing working in the office. I think it's a great project.
- I Okay, thank you very much.

ID Interview
P9 Totally fine.

Participant P10

ID Interview

I First of all, thank you very much for participating in the study...

P10 That's okay, no worries.

I ...and for testing this prototype. I've got a few questions on how you used it and what you thought about it. The first one would be how did you use it, so where did you place it on your body?

P10 Predominantly on the inside of my wrist, so here, 'cause I felt that was the easiest way to put it on and get it off quickly and easily.

I Okay, brilliant so no other places, just there?

P10 No, literally yeah.

I Okay. The prototype featured two different control settings...

P10 Yeah.

I ...you couldn't switch between them but what did you think about them?

P10 I found the second setting that you did a couple of days ago was it meant it got colder.

I Yeah.

P10 But I still found I got used to the coldness after 10 to 15 minutes, it's almost like a numbing feeling where you don't feel... you can feel yourself cooling down but then you don't feel the actual cold on your wrist. But yeah, I think the second setting was better for me.

I Okay. Is there any other way you would just find a difference between the settings?

P10 Not really.

I Okay so it was mainly about the temperature *[inaudible 01:27] cold?

P10 Yeah.

I Do you have any other comments or suggestions, wishes regarding the control or behaviour of the device?

P10 Maybe if there was a higher scope of say from not very cold to really cold, I know you said it's quite... can be dangerous with the motor getting too hot, but if there was a way of making that maybe more safe so that I could have, or the user could have more control over how cold it can get.

I Okay.

P10 I don't know how cold it could get, I don't know what the max setting is, but maybe to make it so I have more scope of temperature. Sometimes it got a bit awkward when I had a meeting and obviously it's quite big, I can't be going in a meeting with it, especially with external clients. That was the only issue, other than that it was good. Really interesting.

I Okay. Did you take it with you to the meetings?

P10 No, I took it off. I was advised to take it off as well just because it might be like, 'What the hell is that?'

I [Laugh] Okay but you would have wished to take it with you?

P10 Yeah, yeah. Especially in the meeting rooms, it's so hot. It would have been really good, but it's fine.

I Okay, that's good to know, thank you very much for the comment. The other thing is, how do you usually, what do you usually use to get cooler?

P10 I think the main thing is try and find either a fan or going near a window if there's a breeze or just drink as much cold water as I can. Other than that, there's not much, we don't have air

ID Interview

conditioning. So, it gets really hot and there's only certain things I can do. The best thing is probably a fan or just to keep drinking.

I Yeah. How would this wearable prototype compare to *[inaudible 03:35] [over speaking]?

P10 To that. I think it's good 'cause it's quicker, it works quicker 'cause it gets cold very quickly. It's just I get used to that level of coldness, so I sometimes feel I can't get myself... I get to a point and I can't get any cooler than that point. So, I might use... then drink more water after that to get even cooler. I suppose there's a max on everything, I can only get cool to a certain extent, depending on my surroundings and what's available. But it's good, it did work.

I Okay, thank you. Do you have any other comments?

P10 I've got a question. What is your fan, with the prototype are you actually going to make it as a product?

I No actually not.

P10 Just as a study?

I Yeah, this particular study was about different control settings. I used the prototype to look at this and in combination with the air cooling of *[inaudible 04:41].

Participant P11

No interview was recorded for P11

Participant P12

ID Interview

I First of all, thank you very much for participating in this study and for testing the prototype. I have some questions on how you used it, and how you experienced the cooling basically. First question I have is, how did you use the prototype, where did you place it on your body?

P12 When I first starting using it, I put it on my wrist and then quickly realised that it was difficult to type, so then I moved it to the top of the arm.

I Okay, thank you. The prototype featured two different control settings, which one did you choose... oh you didn't do the choosing bit, but how would you describe the difference between them?

P12 I didn't notice enough different because when I was using it, it was already quite cold. So, when I was choosing the setting myself, I was just putting it on the lower setting, so *[inaudible 01:21]. I think I'd probably say I preferred the one where it was adjusting by itself.

I Okay.

P12 But again, I think it may have just been going to the warmer setting because it's been cold. It's hard to say.

I Okay, thank you. That's perfect thank you very much. Do you have any comments or issues regarding the control or behaviour of such a cooling device, like anything?

P12 What I was thinking is for some reason, when I was at school I remember somebody telling me to cool yourself down, put some cold water on your wrists, or behind your each, I think pulse points. So, the most natural thing for me was to put the device around your wrist. I think it would be really good if it was small enough to have a *[inaudible 02:20] wrist and you could still type and work *[inaudible 02:24] [background noise]. That would be one thing. The other thing might be quite useful if there was something via feedback, so if there was a way of measuring your own temperature and seeing how the prototype, or the device affected your own

ID Interview

temperature. You might end up using it more or be more invested in using it. Even if it was just... even if it didn't affect the way it worked, you would still have some idea of controlling your own thermal comfort and having control of your own environment. I think that might be something, if that was possible it would be interesting to do.

I Yeah, definitely that's true. In the questionnaire you mentioned that you also have a fan in the office for cooling basically, how would you say this device compares to the fan?

P12 This would be much better, because the fan in the office there's just one and it's over by somebody else's desk basically, so you're not getting much cooling from the fan. I haven't asked for another one 'cause it has been cold recently, but I imagine it would be difficult to get like six or seven fans in the room. So, something like this is much better *[inaudible 03:57] [OVER SPEAKING] [BACKGROUND NOISE] ... for yourself have control over as well, without having to ask *[inaudible 04:03] [OVER SPEAKING] [BACKGROUND NOISE] 'do you mind if I turn the fan down?' *[inaudible 04:05] [OVER SPEAKING] [BACKGROUND NOISE]. *[inaudible 04:08] [OVER SPEAKING] [BACKGROUND NOISE]

I Do you have any suggestions or comments?

P12 I mentioned when we were chatting dinnertime, I think it's really good for in situations where you might get... I didn't actually mention this, but situations where you might get stressed, your temperature goes up, doesn't it, or certainly I feel I can get a bit hotter. So maybe a job interview, that would be really useful to have something like that, that was more compact. The other thing I was thinking about, you mentioned women, menopause, so the other thing is on your monthly cycle changes, so I think the temperature goes up quite a lot in the second half of the cycle? So again, the device would be quite useful for women I think. I don't know if I've got any other ideas or comments. But yeah, what I really liked about it was having the control was really cool and actually having the *[inaudible 05:19] as well, was quite nice to have that. Then the cooling plate as well was very effective, it definitely cooled you down quite well. What I did notice was one day, I was already feeling a bit cold and then I used it and then afterwards my whole arm was chilled for quite a long time! [laugh]

I Oh okay.

P12 I think that's because I was already cold, and I shouldn't have used it. Then I noticed... always my left hand is a bit colder anyways, so the tips of my fingers stayed cold after using it, and then I tried to figure out if that was what happens anyway, but I don't think it is. For some reason my left arm is colder than my right! [slight laugh]

I Okay.

P12 I don't know if you've come across that yet?

I No, not yet. That's a very interesting comment I think I might want to look into that.

P12 I would have to notice it more to follow up, but yeah.

I Okay, thank you so much.

P12 Alright, no problem.

Participant Pilot Study PP1

ID Interview

I *First of all, thank you very much for participating in my pilot study. I have some questions about the use of the prototype and how you found it. I also have some questions about what you said on the questionnaires. The first question I have is how did you use the prototype, if you could show me where you put it?*

PP1 Where I put it? I used the [inaudible 00:00:31], I either used it around here, so the only problem that I had sometimes was to put the strap on by myself and to try and make it tighter. I didn't

ID Interview

know where to put the strap, so when it was up here I tried to put it this way, so that it wasn't covering the [inaudible 00:00:56] with the band itself and I could still turn the knob, so it was around the arm here, and then sometimes I put it... I was trying to put it on my veins in the right place, so I just had it there, and I tried to make it a bit tighter. To be honest the only problem with it sometimes really was to be a bit tricky. Up until here I think it was fine, then I tried to put it on my wrist and 'cause I, sometimes like I told you when I was little as well when I'm in a hot place my nose bleeds a lot and so I'm used to go and put my wrists underneath cold running water.

I was trying to put the prototype on my wrist so that I could cool my blood through my veins, but then I've got quite a small wrist so that was a bit actually of a problem because I can't actually do that and end up, so if I was doing this sometimes I noticed that the prototype would cover it because maybe it was caught in this, so I would try to twist it or put inside so it wouldn't do that. However, then when I was typing, so when I was at the desk, if I was just reading it was fine, but if I was typing then the prototype was a bit in the way, but it was fun when I did it here on the arm, and then I did the same here so for example like yesterday... the first day I only did on my right arm, I'm right handed so then because I noticed as well that when I was moving my arm of course to scribble something as well not just typing. Maybe I would move a lot and because I was moving a lot so the battery was here on the table and if I would turn then the battery, forgetting that I had it, then the battery it would just drop. Then I thought okay I'll put it on my left arm 'cause it's not moving as much, and I did the same, so I was just putting it up here. I tried again to put it on my wrist, but it was just difficult to actually keep in place. What I did yesterday actually I was trying to twist that, so then it will make it shorter, and I just do that so at least everything will be clear, and then what I did because yeah It was a bit... not knowing but it was a bit bulky to have it this side then I twisted it on top, but then that way after the cooling thing knowing the veins where I wanted, it was on top, it was still nice to feel it.

I Okay, thank you and so this prototype featured two different ways of control. Which one did you choose when you were able to switch?

PP1 So I started with the manual one, because I wanted to see whether I could actually perceive the difference as well, because at the beginning when I used it the first time I actually didn't know that there were going to be two different settings so and the first time it kind of overheated as well didn't it from that, then we changed it. I noticed that with the manual one maybe because I could never feel it as much if it was on the low. I felt so maybe I need to put it a bit higher, so I would turn the knob to raise the temperature, well to lower the temperature, but then I noticed that the prototype would overheat a little bit.

It wasn't as much as the previous one, but I could still perceive that there was something warm though, so the thing is that it would dissipate the heat so even though it was the band maybe around here to make it warm so if I could touch that, it would be warm, but even the Velcro around it was quite warm, so then I lowered it down then I tried to do that one more time and it kind of had the same effect, so then I'd switch it to the automatic one let's say, but when I switched it to the automatic one I didn't have the problem of the prototype overheating. I felt actually I didn't have to worry myself and think, "Oh maybe I need to adjust the temperature, or how do I feel?" Because I just forgot about everything in that like when you set the aircon or when you set the thermostat that it would take care of it, so I didn't have to be on it so I think I preferred the automatic setting, because I could forget about it, it could just be on or off and that's it.

I *Okay, yeah thank you that makes sense. Okay regarding the control do you have any other issues or suggestions that would work for you? Or is there anything else you...?*

PP1 Regarding the control? No, I did like the fact of having this radio button, radio knob. You can just turn and unlike the [inaudible 00:07:22] 'cause at least it's clear when you're raising it and when you're lowering it, so I don't think I would change that anyhow, maybe then yeah if you just got the... maybe the only thing would be to have maybe the button on top, rather than have it inside to switch it, but it's nothing major, it's not really about the control itself, maybe just not so that you don't have to open a switch pad.

ID Interview

I *Okay thank you, so in the questionnaire you mentioned that one thing that could be improved is the area, or the size of the area that's cooling.*

PP1 Yes.

I *So, I was wondering...*

PP1 Just because sometimes the cooling effect wasn't as perceivable, so sometimes I would wonder whether it was actually cooling or not, then if I would put my finger in, so that's what I used to do if I had the prototype on then if I wasn't sure. I would just stick my finger into it so that I could touch the cooling bit and then I could feel that it was cool, so I was like, "Oh yeah, no it's cool, it's fine." But sometimes I couldn't perceive it as much, or...I know that sometimes you can get used to it after a while, but maybe it wasn't as big to make a change, so it was a little bit, but wasn't as perceivable to actually say with the heating one for example if I was cold then I'm down, because it was quite large.

I could wrap myself around it and I could actually feel a change in my internal comfort. With this one, probably because it was such a smaller area, I didn't feel much of a change. I think one of the day I was trying not to put the fan on, because I really wanted to see whether that would make a difference, but then one day I think it was too hot, it was the seventh day that I just put the fan on as well as this, but I put the fan on too and I thought maybe if it is a bit larger then you could actually feel it more.

I *Okay, yeah thank you and so you mentioned about the fan that was my next question actually is related to the fan, so because you said that sometimes one of the ways for you to adapt to feel to warm is to put a fan on, so how does the prototype compare to the fan as regards cooling? Obviously, you'd already said the area wasn't large enough by itself.*

PP1 Actually, it's probably because [laughter] when I had this prototype on and the band was running, I could actually feel a bit of a breeze coming off from that, when it was my [inaudible 00:10:46] which was, "Oh that's nice." Because after like I did one of the [inaudible 00:10:50] that just goes and you...[inaudible 00:10:55] I actually think I would prefer something like that than a fan because even though I need a fan, I don't really put it on that much even when I'm at home, because I hate having hair blowing directly at me.

I'm thinking you raise dust as well, because basically it moves the air, that's all a fan does, it's not really cooling as such. It just kind of raise the air movement, and it might give you the impression that it's cooler, but it's not and especially a few minutes [inaudible 00:11:31] it's dusty then sometimes I end up sneezing, because there is just so much dust getting moved by the fan. I prefer these in turn, that I can put these wherever I like and it's not blowing direct at me, because [inaudible 00:11:51] that's with the little fan that I've got, it doesn't move either, than when it's starting because it's a little desk one.

Even though I try not to have it directly on me, even I don't know for what reason, but I feel my eyes get very dry as well with the fan. I like the fact that it's something cool and just on me, like a cool patch or something, so I think I would like if it was a bit bigger, like a cushion or example or...maybe the blanket would be a bit too much to have a cold blanket but yeah a cushion or because I just felt that I wanted that contact, I like the contact with the cold air on my skin, but I just felt it was a bit too small the surface so it could have been a bit bigger than...or maybe a belt with a lot of those ones around.

I *Okay thank you and what I just wondered because this was just one thingy for one side, would you have liked two of those or was it fine to only have this one on at one time?*

PP1 I think it would be nice actually to have a [inaudible 00:13:25]. I think the way that maybe it would work, just without making it larger as well is to have two maybe wristband, so they didn't have to be very big and you could have just covering the wrist area where the veins are, so they would cool the blood. Maybe having one on each side, so I need two that would work perfectly.

Then probably in that case change them to all to [inaudible 00:13:58]. I don't know if there is a way to do it, but rather than having the band cooling, because it's quite bulky, just add something else, so even like a little ice box, that would cool the blood down so there's something a bit slimmer that you can wear and you can forget about it.

ID Interview

That's the thing that I liked about it, when I've got the fan on, I never forget that it's on, it's not because of the noise, but because I feel that there is something blowing on me, and it's not normal when you're inside. I noticed with this one when I do my [inaudible 00:14:34] in the way of the movement I actually forgot about it, and that's why I would just suddenly move or get up of my chair, and the battery then I was worried would drop down, so maybe if it was like two little wristbands that you just put on, I'd love that.

I *Okay thank you so that's all the questions I had.*

PP1 Thank you very much.

Participant Pilot Study PP2

ID Interview

I *Thank you very much for testing my prototype.*

PP2 You're welcome.

I *I have a few questions on how you used it and so on. How did you use it and if you could show me where you put it?*

PP2 Okay. The first day, I used it on my leg. It was like this. I use it for maybe five minutes, because it got quite hot, so I had to remove it. The second day I put it here on my arm but in this case my skin had like zero contact with the cooling area. I saw that it was like, of course my arm is smaller than my leg, so this part like height this sensor I wasn't sure if that was okay or not? Yeah.

I *Okay, thank you. The prototype had two different control settings, when you could choose between them which one did you choose?*

PP2 The second one when the light is on.

I *Okay, so when it adapted?*

PP2 Yeah.

I *You were trying to adapt.*

PP2 I think it gets hot slower so that was why. Maybe just my mind?

I *Okay, so it was because of the heat?*

PP2 Yes.

I *It generated. Is this how you would describe the difference between the two settings basically?*

PP2 Yes, I think the first one it gets hot fast. The second option less fast, [Laugh]

I *Yeah, okay, thank you. Do you have any other comments or any wishes, things you would like in regard to how the device was controlled?*

PP2 I don't know I think there was an issue with the heating. We need to control that I think. Should I talk just about the control or anything relative to the device?

I *And other things.*

PP2 I would like this to be smaller, maybe inside the device, because if you want to stand up and walk you need to take this into account. I like that you can choose how could you want to be with this part. But I didn't have clear how the control, what does the control do?

I *Thank you for the comments. The other thing in one of the questionnaires, or in both maybe, you mentioned that the area of the cooling was not large enough? Would you have any specific size of cooling area in mind or is it...?*

PP2 Not really, I just felt that it was not enough.

I *Yeah.*

PP2 But I don't know maybe if the area is bigger then maybe there is problems with the *[s.l. core 04:47] surface, like your arm or your leg, it has this shape, the cooling area can adapt to the surfaces *[inaudible 04:56]. I don't have a specific area.

I *That's fine I was just wondering. Can I just quickly pick up on something that you said earlier that when you put it on your arm, you said the cooling surface was in direct contact with your skin, was this an issue, did you feel like in comparison to having it on your *[inaudible 05:25] [over speaking]?*

ID Interview

PP2 I think yes, it could be a little bit annoying, maybe [slight laugh] because maybe it's better to have something between this thing and your skin?

I *Okay.*

PP2 It is still feeling cold but not like, ice when you take ice and put it directly on your skin. *[inaudible 05:50] take some coats and do the same. Am I clear?

I *It makes sense, you want something like an interface in between.*

PP2 Yeah.

I *In the questionnaire you also indicated that you felt some discomfort wearing the device, in one of the ratings – it was part of the last bit of ratings. Can you explain which part it was, or all of it, like the heat, the direct contact, or...?*

PP2 Okay, I think the discomfort came for two reasons.

The first one is I've been getting hot, like it becomes annoying then you need to take it off.

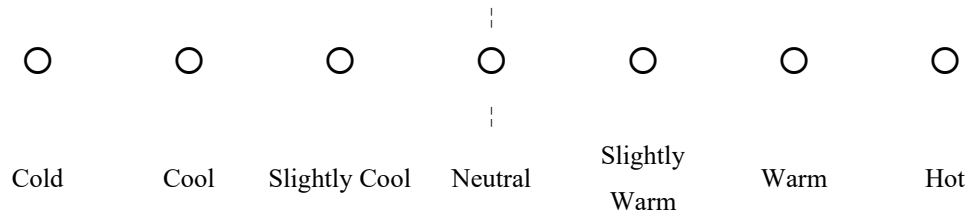
The second one when I put it here, I think maybe I was using it wrong, but it was going down like quite easy, I tried to adjust it, but it was not firm.

I *Okay, cool, thank you very much. You said other things you do when you feel hot, among others that you use a fan, not very often but you do. So how does this compare in regard to something that you put on your body? Which one do you think you prefer, or what other device?*

E.4. Environmental Data and Right-Now Survey Results

Answers to the following questions are depicted in the graphs:

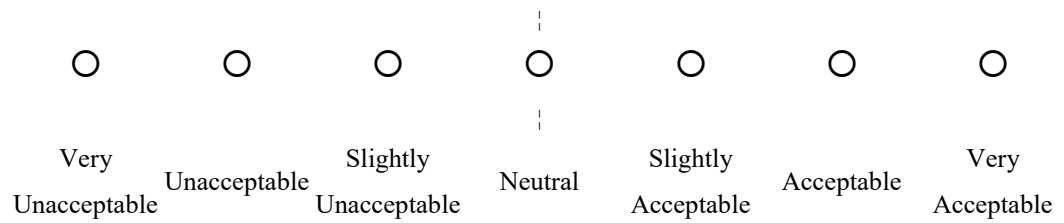
1. How do you feel right now?



2. Would you like to be

- Cooler
- No change
- Warmer

3. How acceptable is the temperature to you?

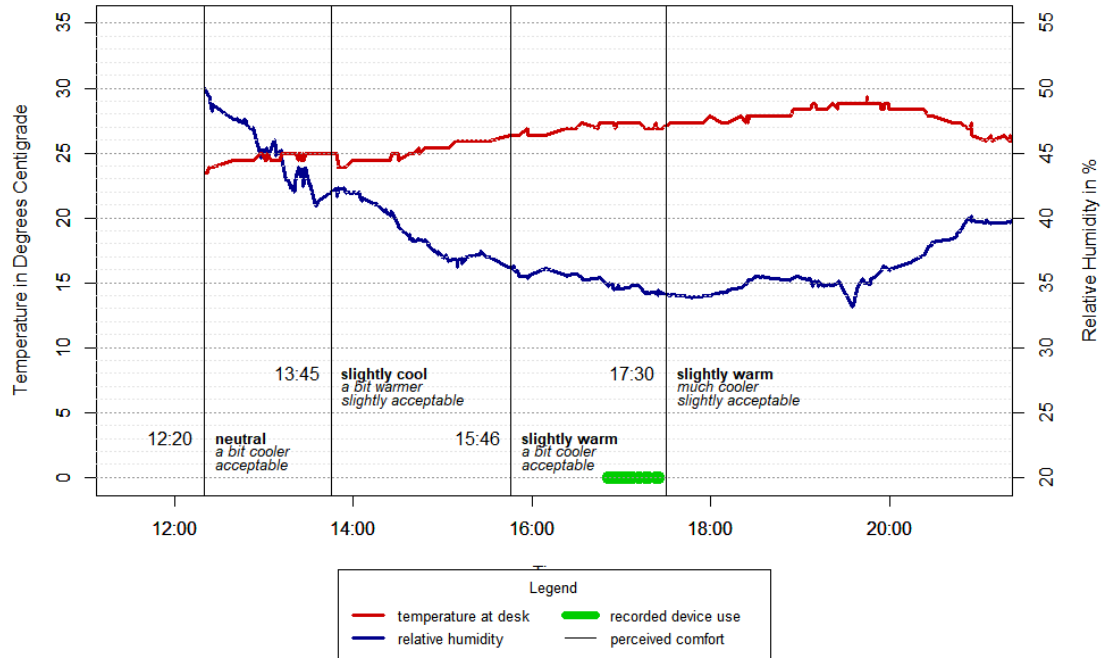


Participant P1

Manual Control Mode

P1 – Manual Control – Day 1

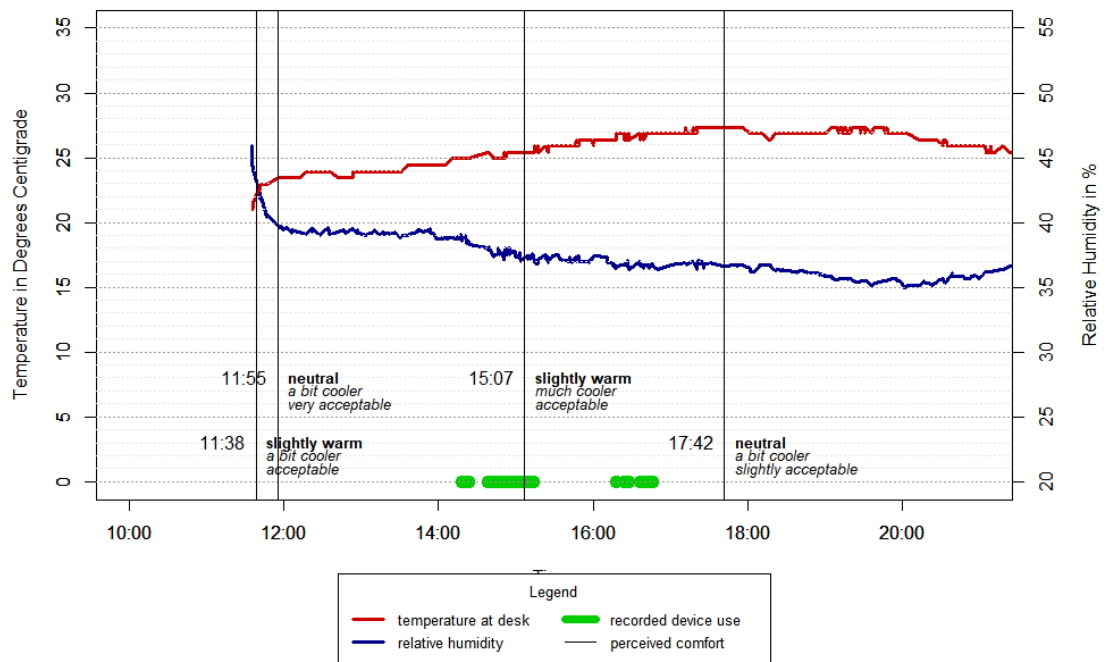
P1 – Day 1: 12/08/2016, Room A, Manual Control Mode



Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
12:20	Seated (passive)	Window(s) open, Lights on	Cold	
13:45	Seated (active)	Air movement too high/low, Drafts from windows/vents Lights on	Cold, Hot	Window(s) (close) I felt cool
15:46	Seated (active)	Lights on		
17:30	Seated (active)	Incoming sun Window(s) open, Lights on	Room temperature	Prototype (on), Window(s) (open) I felt warm

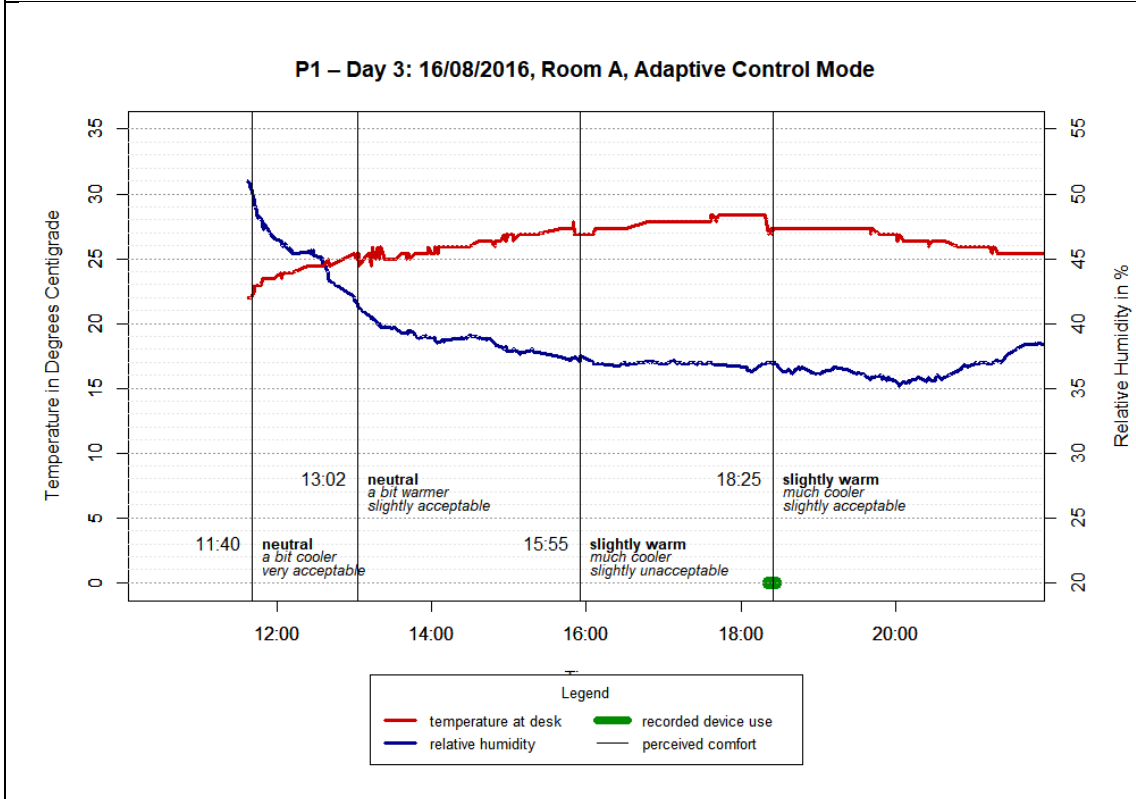
P1 – Day 2: 15/08/2016, Room A, Manual Control Mode



Outdoor Weather	Partly cloudy (am), clear/sunny (pm)
Clothing	Short sleeved shirt/top, Shorts/short skirt, Short socks, Tights/legging, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device use / Behavioural Adaptation
11:38	Walking (outdoors)	Window(s) open, Lights on, Fan on		
11:55	Seated (active)	Window(s) open, Lights on		Fan (down) I felt cool
15:07	Seated (active)	Window(s) open, Lights on, Fan on	Cold	Fan (up), Prototype (on) I felt warm
17:42	Seated (active)	Air movement too high/low, Incoming sun Window(s) open, Lights on	Room temperature	Fan (down), Prototype (off) I felt cool (too much air movement; was out of office shortly and did not turn prototype on again)

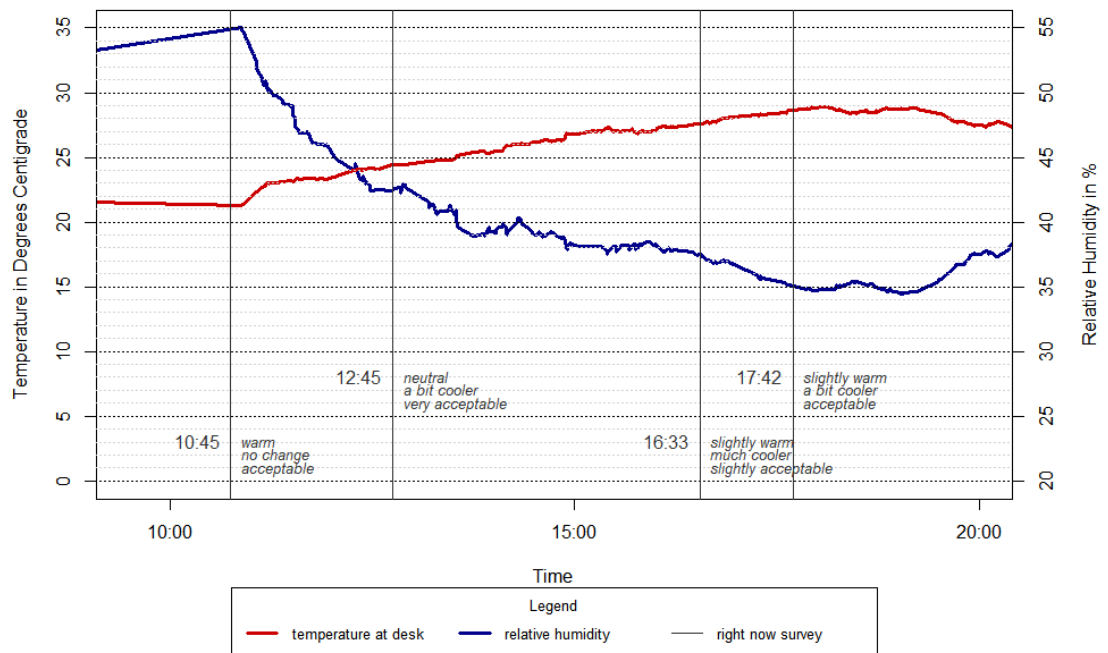
P1 – Ambient Control Mode – Day 3



Outdoor Weather	Partly cloudy, clear/sunny (evening)
Clothing	Short sleeved shirt/top, Shorts/short skirt, Short socks, Tights/legging, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:40	Seated (active)	Window(s) open, Lights on		
13:02	Seated (active)	Other (too low temperature in general) Window(s) open, Lights on, Fan on (not personal fan of co-worker which is pointed away from me)	Room temperature	Item of clothing (on) I felt cool
15:55	Seated (active)	Air movement too high/low, Incoming sun Window(s) open, Lights on, Fan on (not personal fan of co-worker which is pointed away from me)	Room temperature	Item of clothing (off) I felt warm
18:25	Seated (active)	Incoming sun, Personal device provides not enough cooling Window(s) open, Lights on	Room temperature	Prototype (on) I felt warm

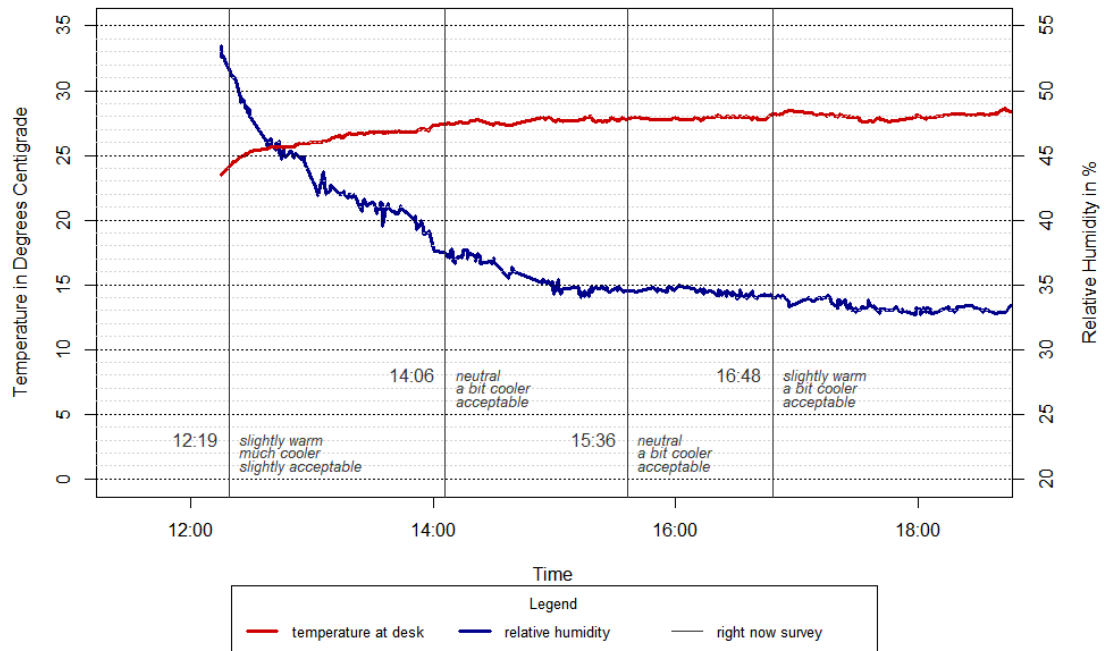
P1 – Day 4: 17/08/2016, Room A, Adaptive Control Mode



Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Vest/sleeveless top (short sleeved cardigan), Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:45	Walking (outdoors) (fast pace)	Window(s) open, Lights on, Fan on		Fan (up), Prototype (on) I felt hot
12:45	Seated (active)	Window(s) open, Lights on,		Fan (down) Other (I left office)
16:33	Seated (active)	Air movement too high/low, Incoming sun Window(s) open, Lights on, Fan on (not my personal fan)	Room temperature	
17:42	Seated (active)	Air movement too high/low Window(s) open, Lights on, Fan on (not my personal fan)	Room temperature	

P1 – Day 5: 18/08/2016, Room A, Selective Control Mode



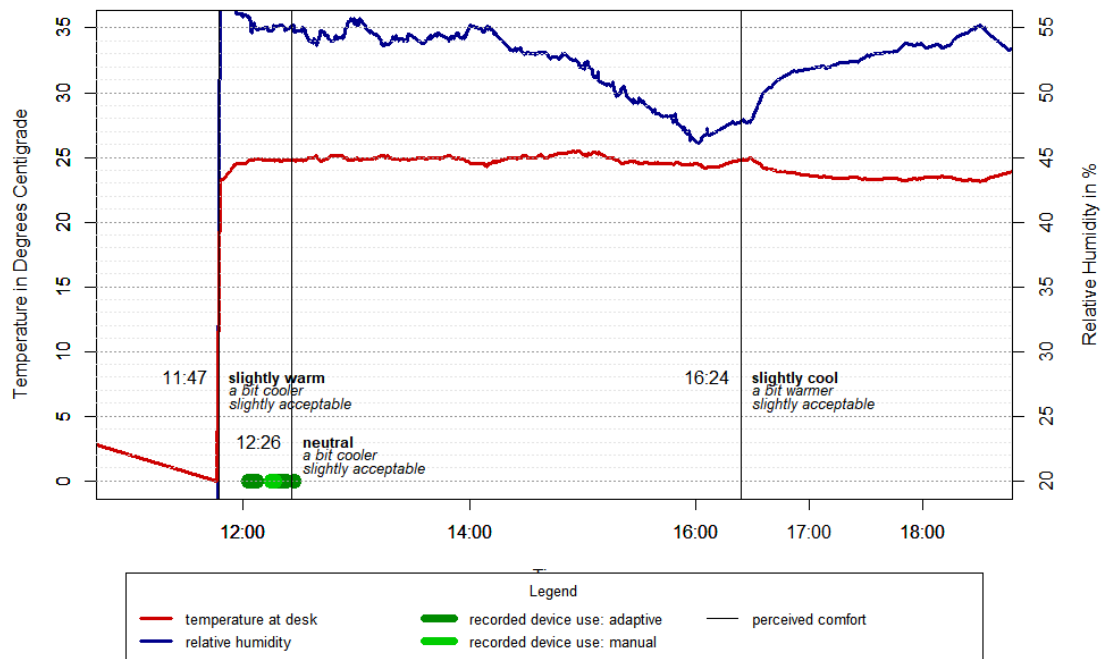
Outdoor Weather	Cloudy/grey or Partly cloudy
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:19	Seated (active)	Air movement too high/low (too low), Other (a bit too warm in general) Window(s) open, Lights on	Cold	
14:06	Seated (active)	Window(s) open, Lights on	Cold	
15:36	Seated (active)	Window(s) open, Lights on	Cold, Room temperature	
16:48	Seated (active)	Window(s) open, Lights on	Room temperature	

Comments	(1) "It is too hot."
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P1 – Both Control Modes – Day 6

P1 – Day 6: 19/08/2016, Room A, Selective Control Mode



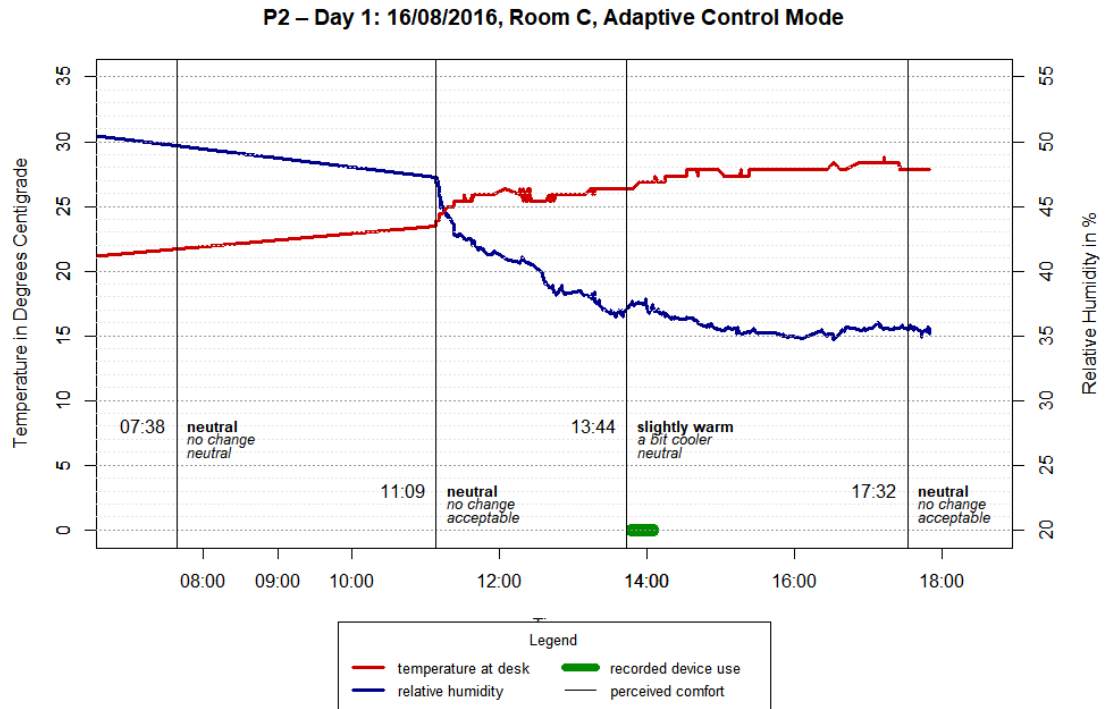
Outdoor Weather	Cloudy/grey, Drizzly to Rainy
Clothing	Short sleeved shirt/top, Trousers/long skirt, Jumper/Cardigan/Sweatshirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:47	Seated (active)	Other (too humid) Window(s) open, Lights on	Cold	
12:26	Seated (active)	Other (too humid) Window(s) open, Lights on	Cold, Room temperature	Prototype (on) Other (to test it)
16:24	Seated (active)	Drafts from windows/vents, Other (too humid and cold) Window(s) open, Lights on		Prototype (off) Other (I left room)

Comments	I was just in a couple of hours and had a long meeting somewhere else -> so just 3 assessments.
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Participant P2

P2 – Ambient Control Mode – Day 1

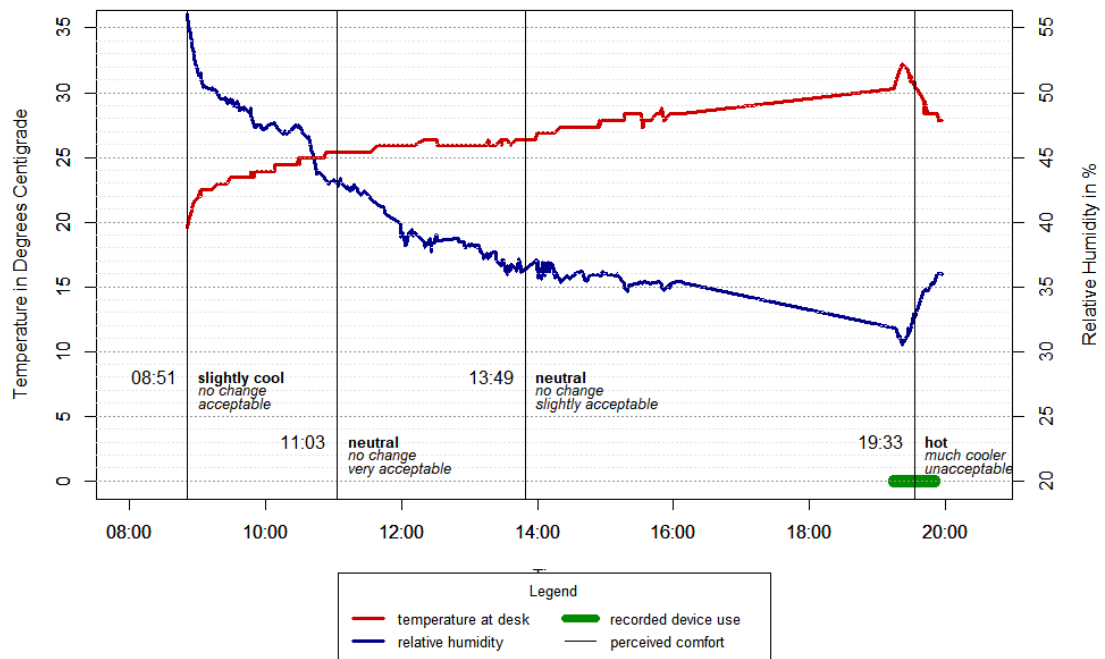


Outdoor Weather	Clear/sunny to partly cloudy (evening)
Clothing	Short sleeved shirt/top, Shorts/short skirt, Long socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
07:38	Walking (indoors)	Window(s) open, Lights on	Room temperature	
11:09	Seated (passive)	Window(s) open, Lights on	Room temperature	
13:44	Walking (outdoors)	Hot surrounding surfaces Window(s) open, Lights on	Room temperature	Prototype (on) I felt warm
17:32	Seated (active)	Door open, Window(s) open, Lights on	Room temperature	

Comments	The prototype has a cooling part and a banding area. When I turn on the prototype, the cooling part was working very nice, it generated enough cool. However, the banding covered my body made me feel even hotter. So I circle the prototype around my leg and arm, hoping to even the temperature.
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P2 – Day 2: 17/08/2016, Room C, Adaptive Control Mode

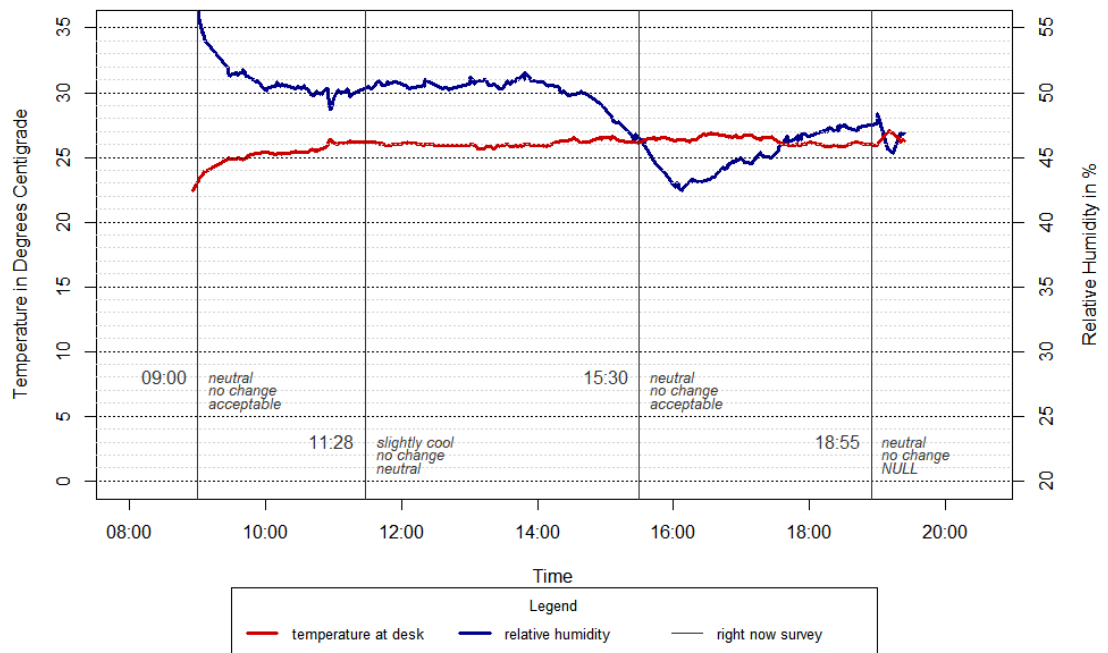


Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
08:51	Walking (indoors)	Window(s) open, Lights on	Room temperature	
11:03	Seated (active)	Window(s) open, Lights on	Room temperature	
13:49	Walking (outdoors)	Air movement too high/low (too low) Door open, Window(s) open, Lights on	Room temperature	
19:33	Seated (active)	Air movement too high/low (too low), Incoming sun, Hot surrounding surfaces Window(s) open, Lights on	Room temperature	Prototype (on) I felt hot

Comments	The office window towards west, so it always get hot in the late afternoon. The cooling device is very helpful for lowering down body temperature. At least it make me feel so both physically and emotionally.
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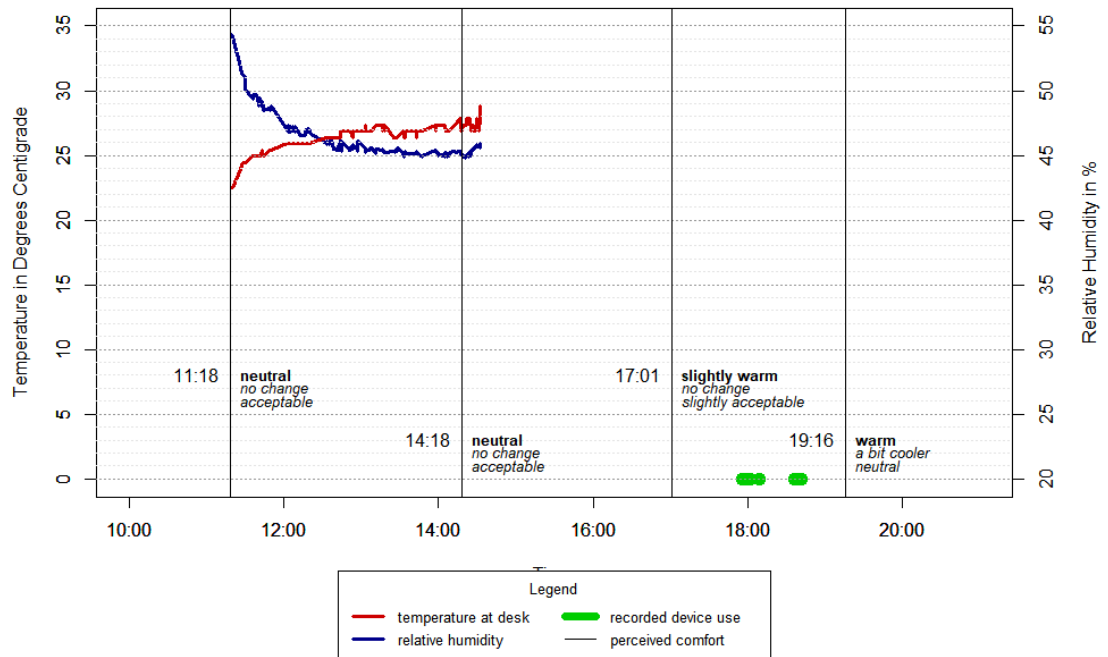
P2 – Day 3: 19/08/2016, Room C, Manual Control Mode



Outdoor Weather	Drizzly to Partly cloudy (evening)
Clothing	Short sleeved shirt/top, Shorts/short skirt, Short socks, Sandals

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:00	Seated (passive)	Window(s) open, Lights on		
11:28	Seated (passive)	Window(s) open, Lights on	Room temperature	
15:30	Walking (outdoors)	Door open, Window(s) open, Lights on		
18:55	Seated (passive)	Door open, Window(s) open, Lights on	Room temperature	

P2 – Day 4: 22/08/2016, Room C, Manual Control Mode



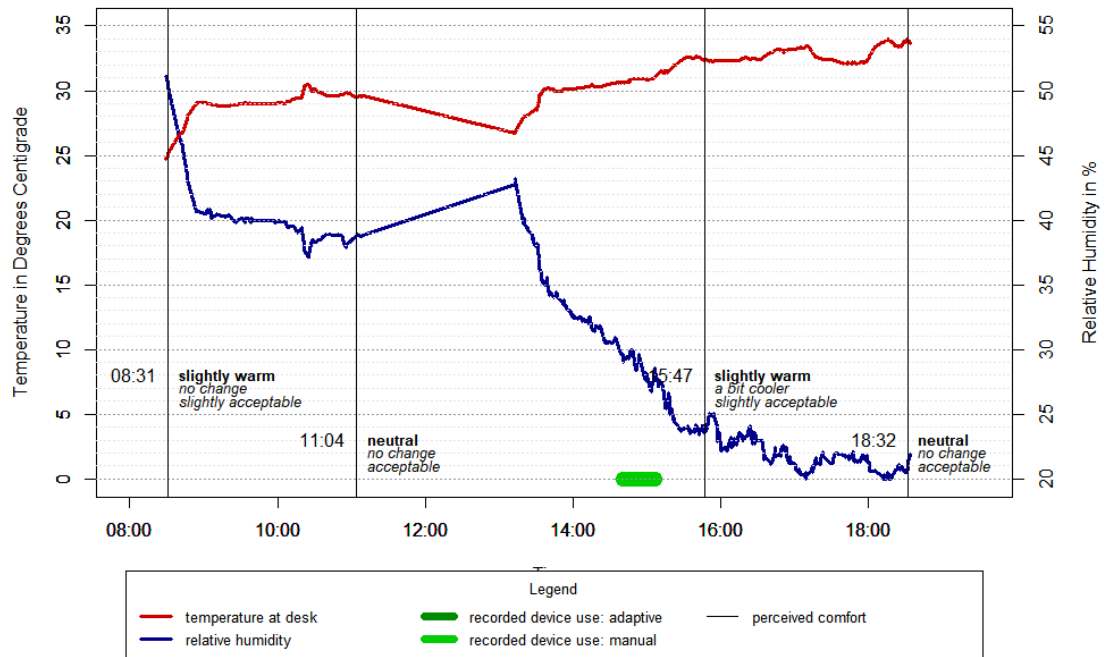
Outdoor Weather	Partly cloudy
Clothing	Short sleeved shirt/top, Vest/sleeveless top, Trousers/long skirt, Long socks, Sandals

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:18	Walking (indoors), Walking (outdoors)	Window(s) open, Lights on		
14:18	Standing (passive), Walking (outdoors)	Window(s) open, Lights on		
17:01	Seated (active)	Window(s) open, Lights on	Room temperature	
19:16	Standing (passive)	Hot surrounding surfaces Window(s) open, Lights on	Room temperature	Prototype (on, twice) I felt hot

Comments	Local cooling can make me feel cool on the whole body level. But when I turn the device off, I started to feel hot again. It would be better to add some automation settings. I feel this type is more easy to control and the cooling is more effective. But at some point I power it too much and the device is not very enjoyable since it generate too much cooling. It has pros and cons.
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P2 – Both Control Modes – Day 5

P2 – Day 5: 26/08/2016, Room C, Selective Control Mode

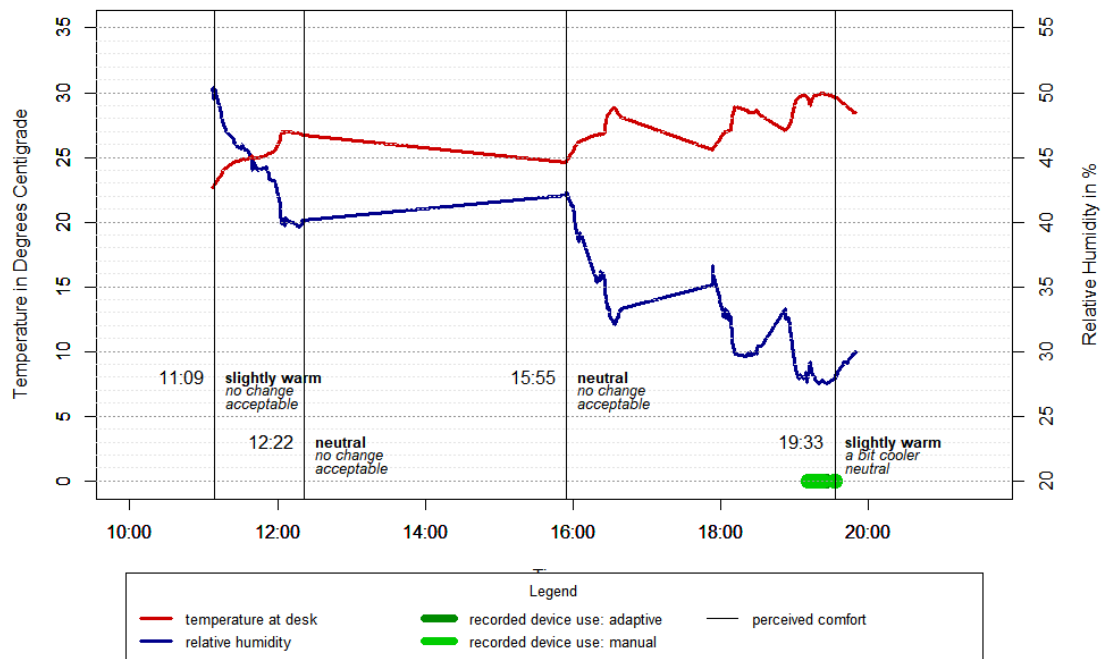


Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Vest/sleeveless top, Shorts/short skirt, Sandals

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
08:31	Walking (outdoors)	Cold surrounding surfaces Window(s) open, Lights on		
11:04	Seated (passive)	Window(s) open, Lights on	Room temperature	
15:47	Seated (passive)	Cold surrounding surfaces Window(s) open, Lights on	Room temperature	Prototype (on/off, when the prototype became hot, I turn off it.) I felt hot
18:32	Seated (passive)	Window(s) open, Lights on	Room temperature	

Comments	When I feel hungry at night, I do not feel hot anymore. But I keep using the device because cooling can help me concentrate on my work.
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P2 – Day 6: 29/08/2016, Room C, Selective Control Mode



Outdoor Weather	Partly cloudy(am) to clear/sunny (pm)
Clothing	Dress, Sandals

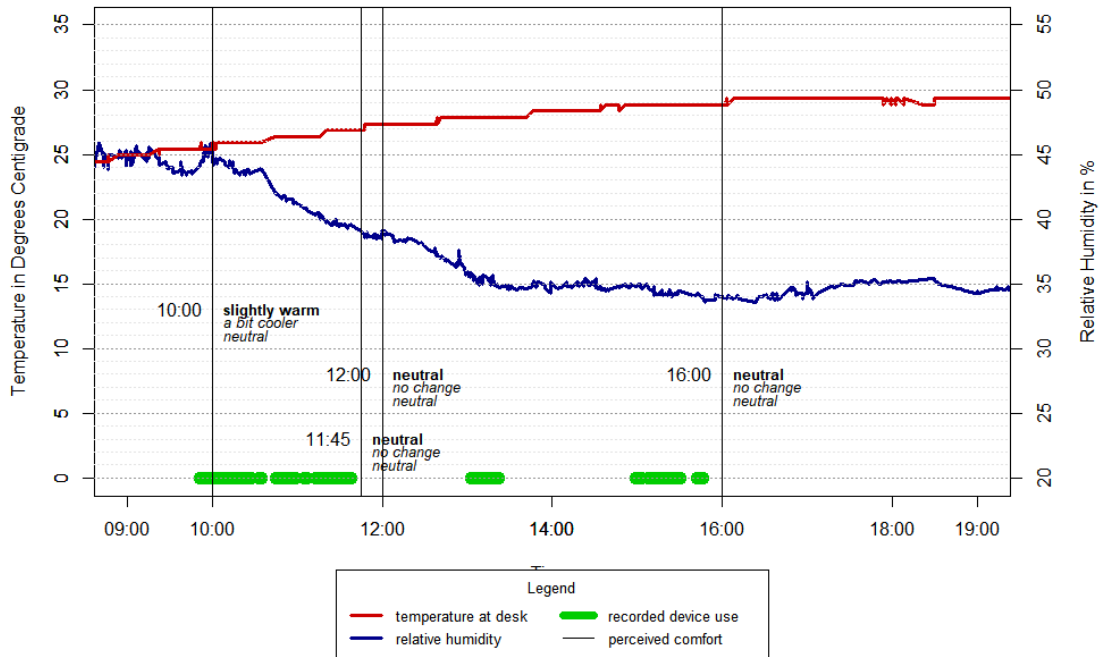
Data Points	Activity Level prior to survey	Environment	Drink	Device Use / Behavioural Adaptation
11:09	Walking (outdoors)	Window(s) open, Lights on		
12:22	Seated (passive)	Window(s) open, Lights on		
15:55	Walking (indoors), Walking (outdoors)	Window(s) open, Lights on		
19:33	Seated (passive)	Hot surrounding surfaces Window(s) open, Lights on		Prototype (on) I felt warm

Comments	If I wear the prototype for a while without moving it, I started to get used to the temperature and didn't feel anymore coolings. Whenever this happens, I manually adjust it's positions. When the temperature is warm, I like the first mode. When I feel really hot, I prefer to adjust the temperature by myself. Because I's like to cool down as fast as possible.
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Participant P3

P3 – Manual Control Mode – Day 1

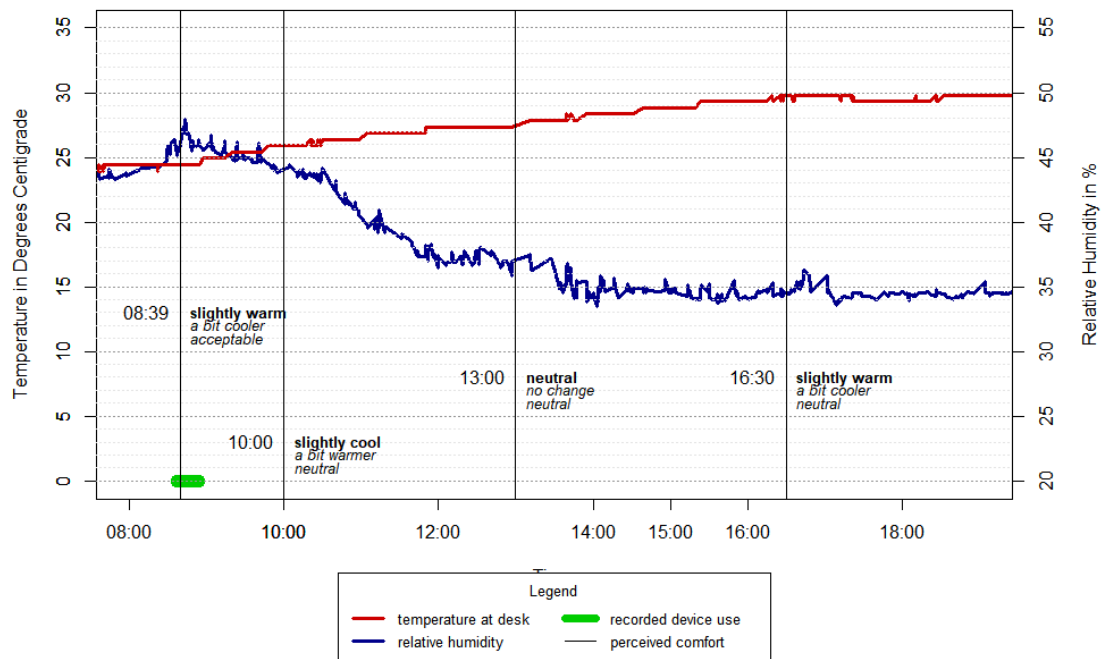
P3 – Day 1: 16/08/2016, Room B, Manual Control Mode



Outdoor Weather	Partly cloudy and cloudy/grey; clear/sunny (16:00)
Clothing	Short sleeved shirt/top, Shorts/short skirt, Sandals

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:00	Walking (outdoors)	Air condition provides not enough cooling Door open, Window(s) open, Other (ventilation)	Hot	Item of clothing (off), Heating (down), Fan (down), Prototype (on), Window(s) (open) I felt warm
11:45	Seated (active)	Other (ventilation is too noisy) Door open, Window(s) open, Other (ventilation)		Prototype (off) I felt cool
12:00	Seated (active)	Other (ventilation is too noisy) Door open, Window(s) open, Other (ventilation)		
16:00	Seated (active)	Other (ventilation is too noisy) Door open, Window(s) open, Other (ventilation)		Prototype (on) I felt cool

P3 – Day 2: 17/08/2016, Room B, Manual Control Mode

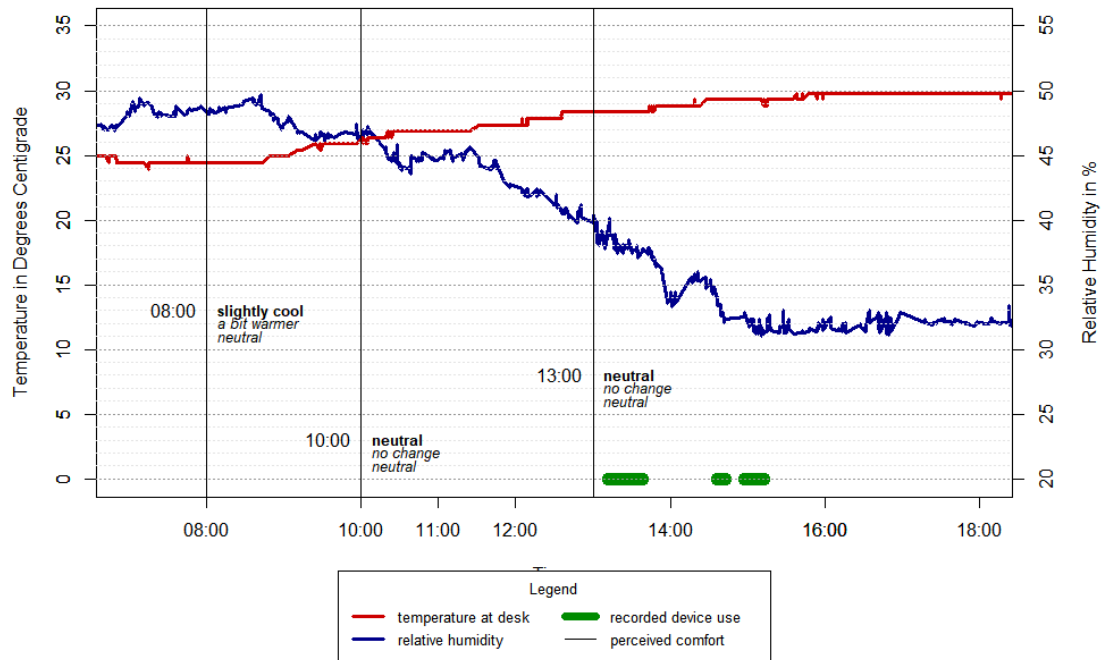


Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Shorts/short skirt, Sandals

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
08:39	Walking (outdoors)	Door open, Window(s) open, Other (ventilation)		Prototype (on) I felt warm
10:00	Seated (active)	Door open, Window(s) open, Other (ventilation)		Prototype (off) I felt cool
13:00	Seated (active)	Door open, Window(s) open, Other (ventilation)		
16:30	Seated (active)	Door open, Window(s) open, Other (ventilation)		

P3 – Ambient Control Mode – Day 3

P3 – Day 3: 18/08/2016, Room B, Adaptive Control Mode

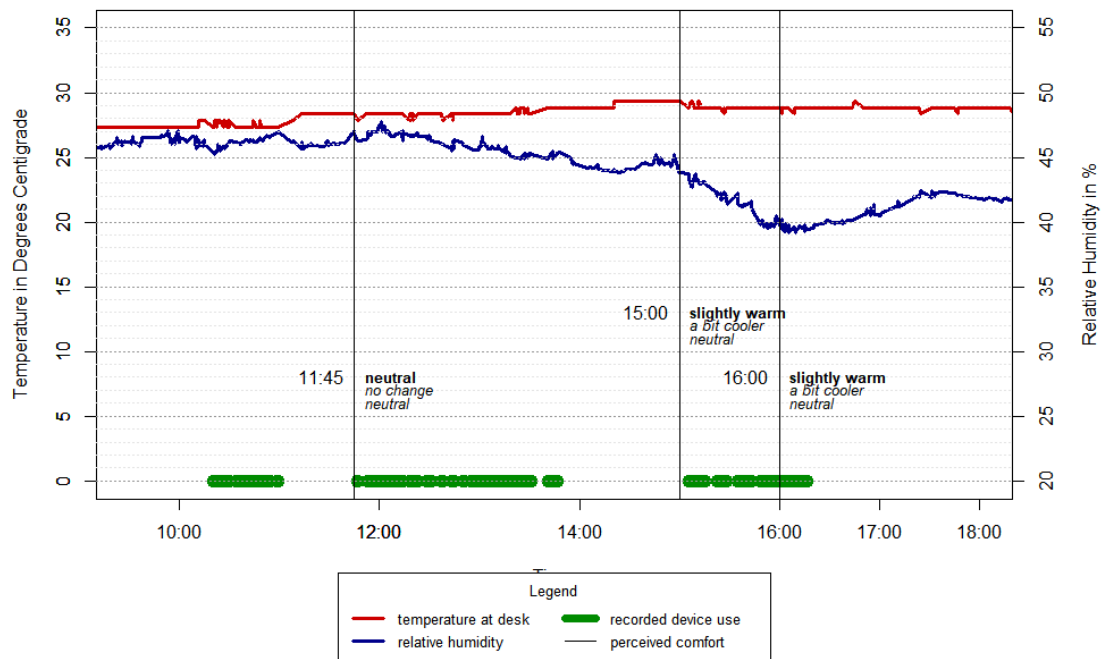


Outdoor Weather	Cloudy/grey to partly cloudy
Clothing	Short sleeved shirt/top, Shorts/short skirt, Sandals

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
08:00	Walking (outdoors)	Door open, Window(s) open, Other (ventilation)	Hot	
10:00	Seated (active)	Door open, Window(s) open, Other (ventilation)		
13:00	Walking (outdoors)	Door open, Window(s) open, Other (ventilation)	Cold	Prototype (on)

Comments	
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P3 – Day 4: 19/08/2016, Room B, Adaptive Control Mode

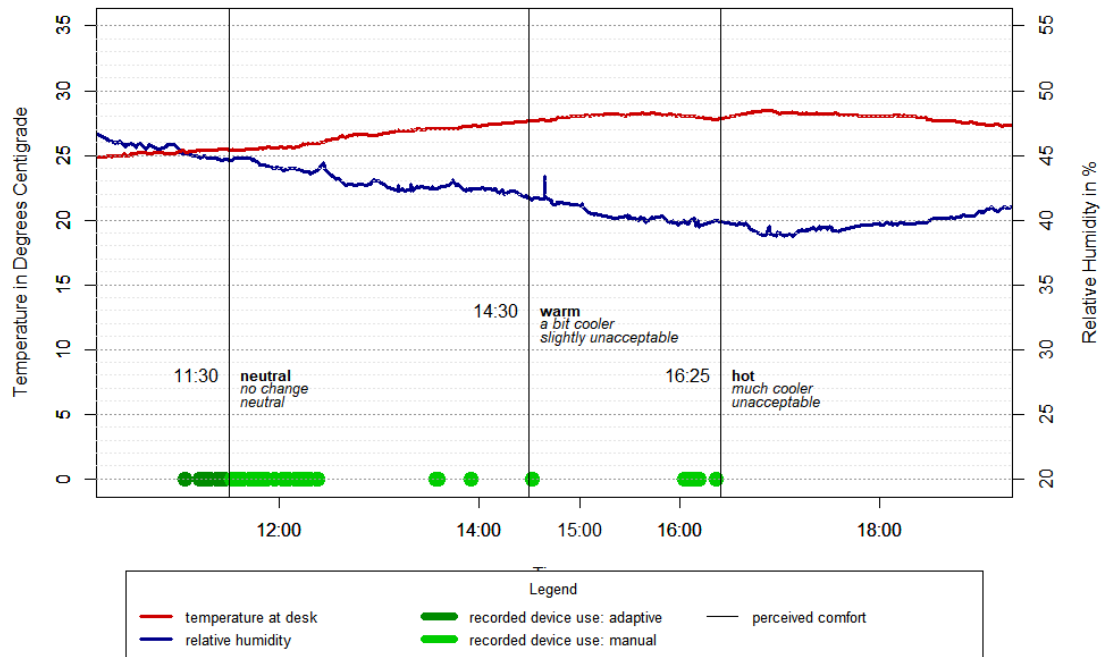


Outdoor Weather	Drizzly (am), Cloudy/grey (pm)
Clothing	Short sleeved shirt/top, Trousers/long skirt, Long socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:45	Walking (outdoors)	Door open, Window(s) open, Other (ventilation)	Hot	Prototype (on) I felt warm
15:00	Seated (active)	Door open, Window(s) open, Other (ventilation)		Prototype (off) I felt warm
16:00	Standing (active)	Door open, Window(s) open, Other (ventilation)		

Comments	
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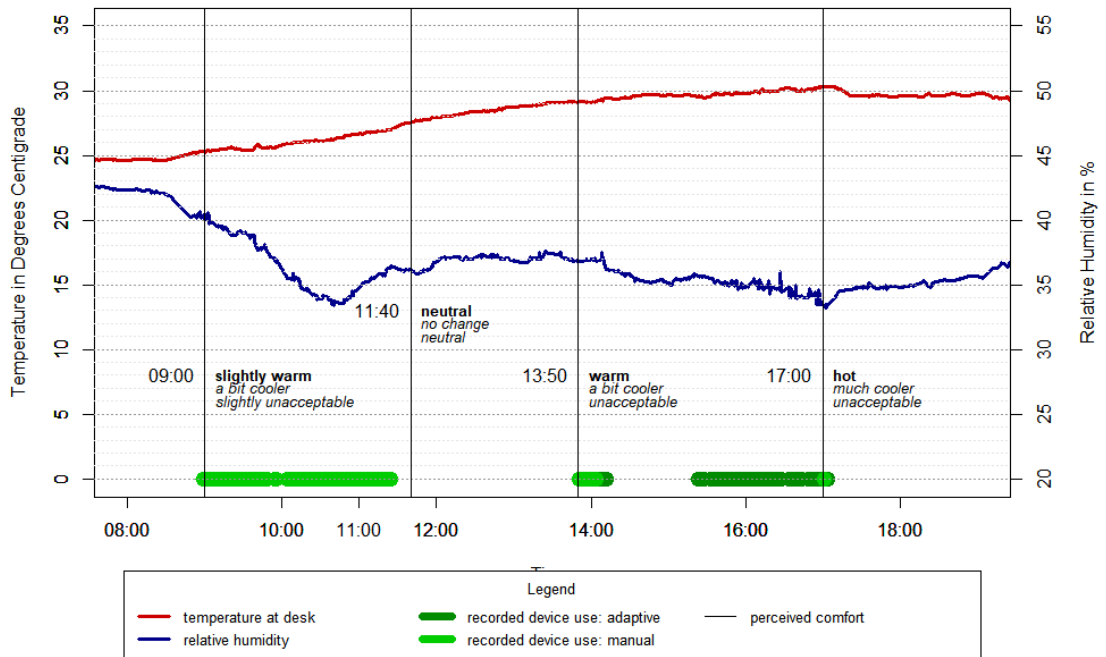
P3 – Day 5: 22/08/2016, Room B, Selective Control Mode



Outdoor Weather	Partly cloudy (am), Clear/sunny (pm)
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:30	Seated (active)	Door open, Window(s) open, Other (vent)		Prototype (on)
14:30	Seated (active)	Air movement too high/low (too low), Air condition provides not enough cooling Door open, Window(s) open, Other (vent)		Prototype (off) I felt warm
16:25	Seated (active)	Air movement too high/low (too low), Air condition provides not enough cooling Door open, Window(s) open, Other (vent)		

P3 – Day 6: 23/08/2016, Room B, Selective Control Mode



Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Shorts/short skirt, Sandals

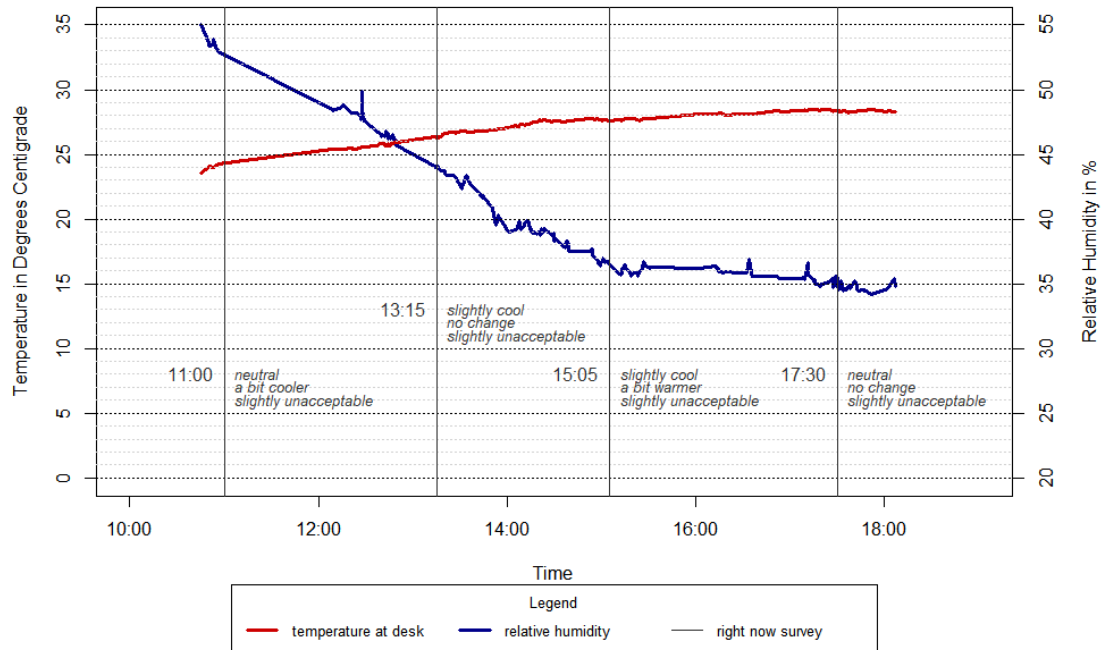
Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:00	Walking (outdoors)	Other (vent) Door open, Window(s) open	Room temperature	Prototype (on) I felt warm
11:40	Seated (active)	Other (vent) Door open, Window(s) open		Prototype (off) I felt cool
13:50	Seated (active)	Other (vent) Door open, Window(s) open		Prototype (on) I felt hot
17:00	Seated (active)	Other (vent) Door open, Window(s) open		Prototype (off) I felt hot

Comments	
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Participant P4

P4 – Ambient Control Mode – Day 1

P4 – Day 1: 18/08/2016, Room A, Adaptive Control Mode



Outdoor Weather	Partly cloudy
Clothing	Short sleeved shirt/top, Trousers/long skirt, Sandals

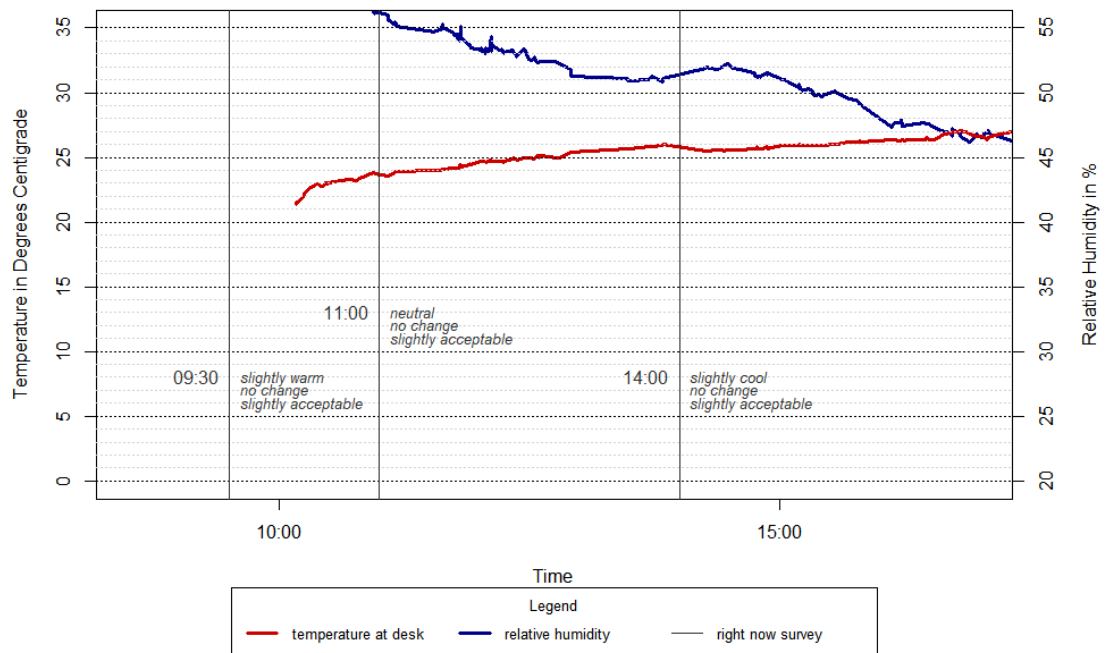
Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:00	Seated (active)	Air movement too high/low (too low), Air condition provides not enough cooling Window(s) open, Lights on		Prototype (on) I felt warm
13:15	Walking (indoors)	Air movement too high/low (too low), Air condition provides not enough cooling Window(s) open, Lights on, Fan on	Room temperature	Prototype (on) I felt warm
15:05	Seated (active)	Air movement too high/low (too low), Air condition provides not enough cooling, Personal device provides too much cooling Window(s) open, Lights on, Fan on		Prototype (off) I felt cool

17:30	Seated (active)	Air movement too high/low (too low), Air condition provides not enough cooling Window(s) open, Lights on		Prototype (off)
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Comments	(3) Didn't put prototype back on - ?.
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P4 – Ambient Control Mode – Day 2

P4 – Day 2: 22/08/2016, Room A, Adaptive Control Mode



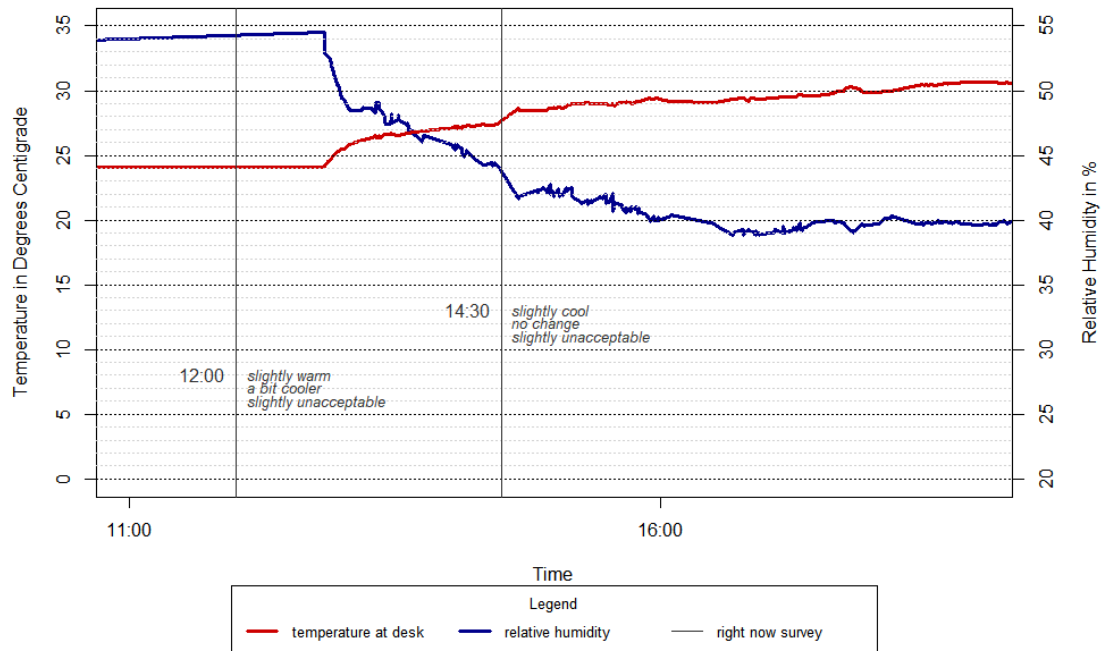
Outdoor Weather	Cloudy/grey, Humid
Clothing	Long sleeved shirt/top, Trousers/long skirt

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:30	Seated (active)	Air movement too high/low Window(s) open, Lights on		
11:00	Seated (active)	Window(s) open, Lights on		Item of clothing (on) I felt cool
14:00	Seated (active)	Window(s) open, Lights on		Prototype (on) I felt warm

Comments	
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P4 – Manual Control Mode – Day 3

P4 – Day 3: 23/08/2016, Room A, Manual Control Mode

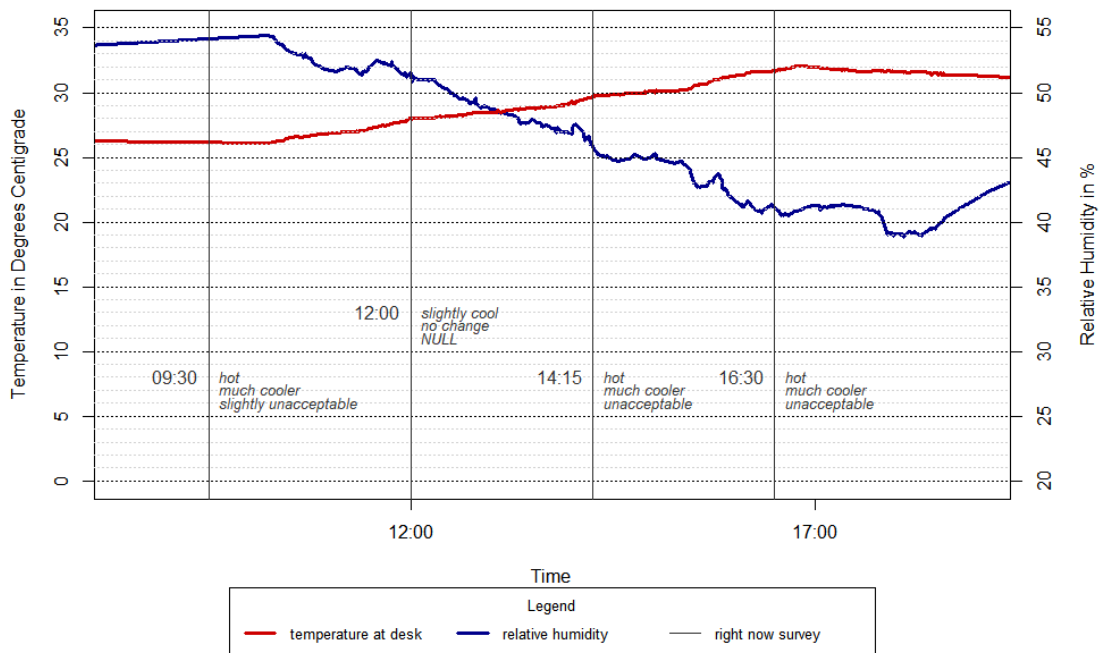


Outdoor Weather	Clear/sunny
Clothing	Long sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:00	Walking (outdoors)	Air movement too high/low Window(s) open, Fan on	Hot	
14:30	Seated (active)	Air movement too high/low Window(s) open, Fan on		Prototype (on) I felt warm

P4 – Manual Control Mode – Day 4

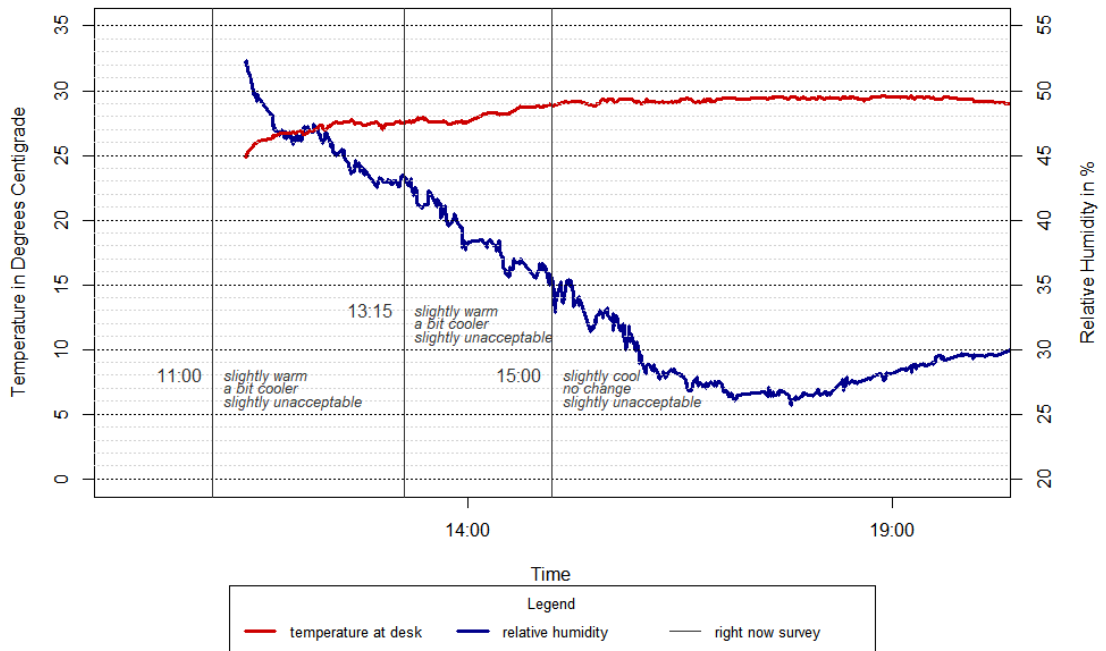
P4 – Day 4: 24/08/2016, Room A, Manual Control Mode



Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:30	Seated (active)	Air movement too high/low (too low), Air condition provides not enough cooling Window(s) open, Lights on, Fan on		Item of clothing (off), Fan (up), Window(s) (open) I felt hot
12:00	Seated (active)	Air movement too high/low (too low), Air condition provides not enough cooling Window(s) open, Lights on, Fan on		Prototype (on) I felt hot
14:15	Walking (indoors)	Air condition provides not enough cooling, Other Window(s) open, Lights on, Fan on		I felt hot
16:30	Seated (active)	Air condition provides not enough cooling, Other Window(s) open, Lights on, Fan on		Prototype (on) I felt hot

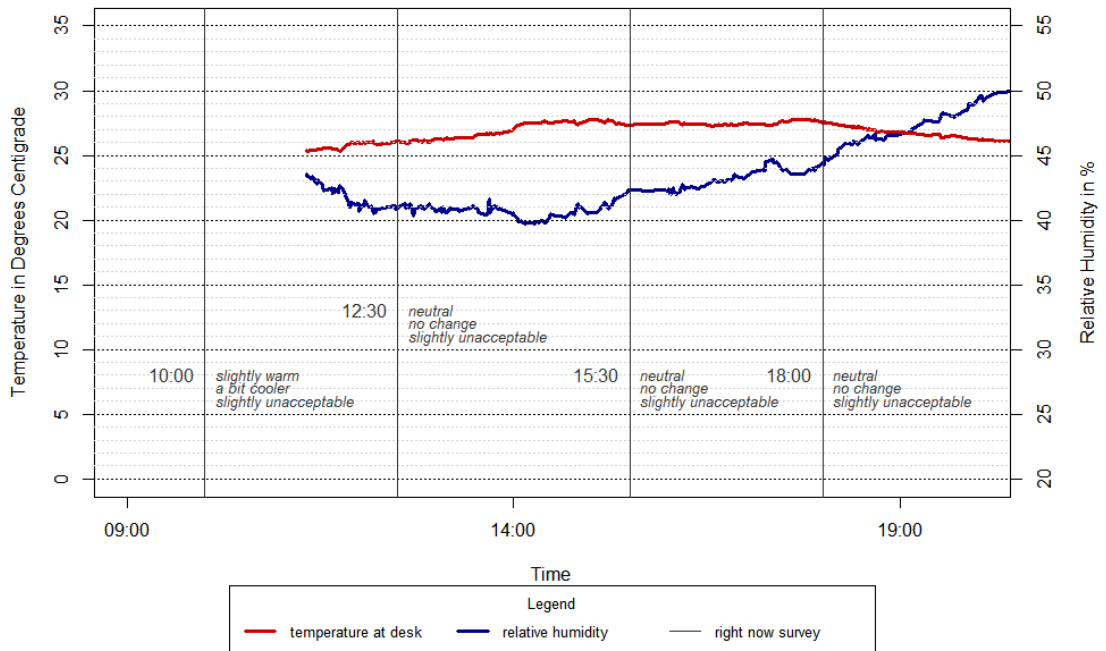
P4 – Day 5: 26/08/2016, Room A, Selective Control Mode



Outdoor Weather	Partly cloudy (am) to clear/sunny (pm)
Clothing	Short sleeved shirt/top, Shorts/short skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:00	Seated (active)	Air movement too high/low, Air condition provides not enough cooling Window(s) open, Lights on		
13:15	Seated (active)	Air movement too high/low, Air condition provides not enough cooling Window(s) open, Lights on		
15:00	Seated (active)	Air movement too high/low, Air condition provides not enough cooling Window(s) open, Lights on		Prototype (on) I felt warm

P4 – Day 6: 31/08/2016, Room A, Selective Control Mode



Outdoor Weather	Partly cloudy
Clothing	Short sleeved shirt/top, Shorts/short skirt, Short socks, Shoes

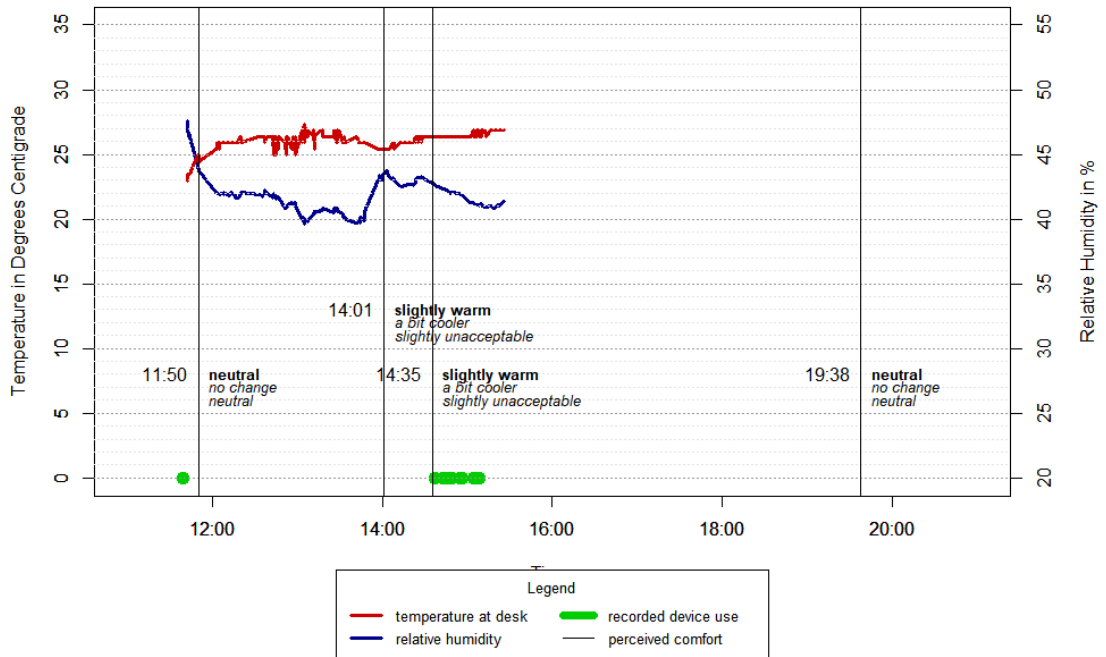
Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:00	Seated (active)	Air movement too high/low, Air condition provides not enough cooling Window(s) open, Lights on		Window(s) (open) I felt warm
12:30	Seated (active)	Air movement too high/low, Air condition provides not enough cooling Window(s) open, Lights on		
15:30	Seated (active)	Air movement too high/low, Air condition provides not enough cooling Window(s) open, Lights on		
18:00	Seated (active)	Air movement too high/low, Air condition provides not enough cooling Window(s) open, Lights on		

Comments	(1) I took the cover I put on the air-con during winter. It made no difference! It's not turned on.
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Participant P5

P5 – Manual Control Mode – Day 1

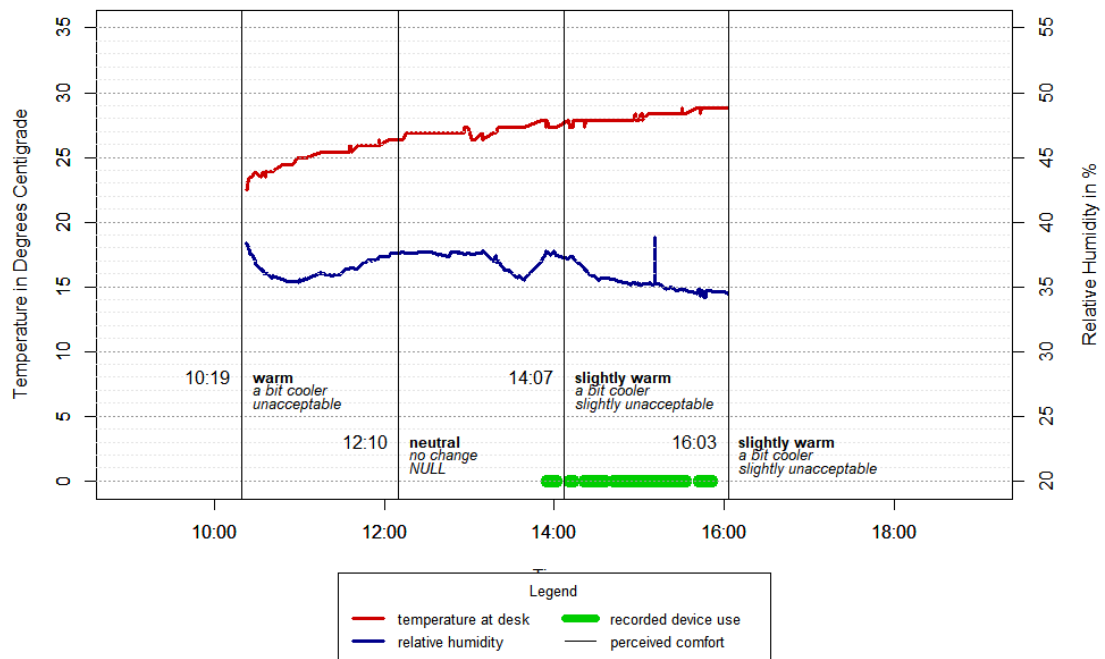
P5 – Day 1: 22/08/2016, Room C, Manual Control Mode



Outdoor Weather	Partly cloudy (am) to Clear/sunny (pm)
Clothing	Long sleeved shirt/top, Short socks, Tights/legging, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:50	Seated (active)	Window(s) open, Lights on		
14:01	Walking (indoors)	Window(s) open, Lights on, Fan on	Hot	Fan (up) I felt warm
14:35	Seated (active)	Window(s) open, Lights on, Fan on	Room temperature	Prototype (on) I felt warm
19:38	Walking (indoors)	Window(s) open, Lights on		

P5 – Day 2: 23/08/2016, Room C, Manual Control Mode

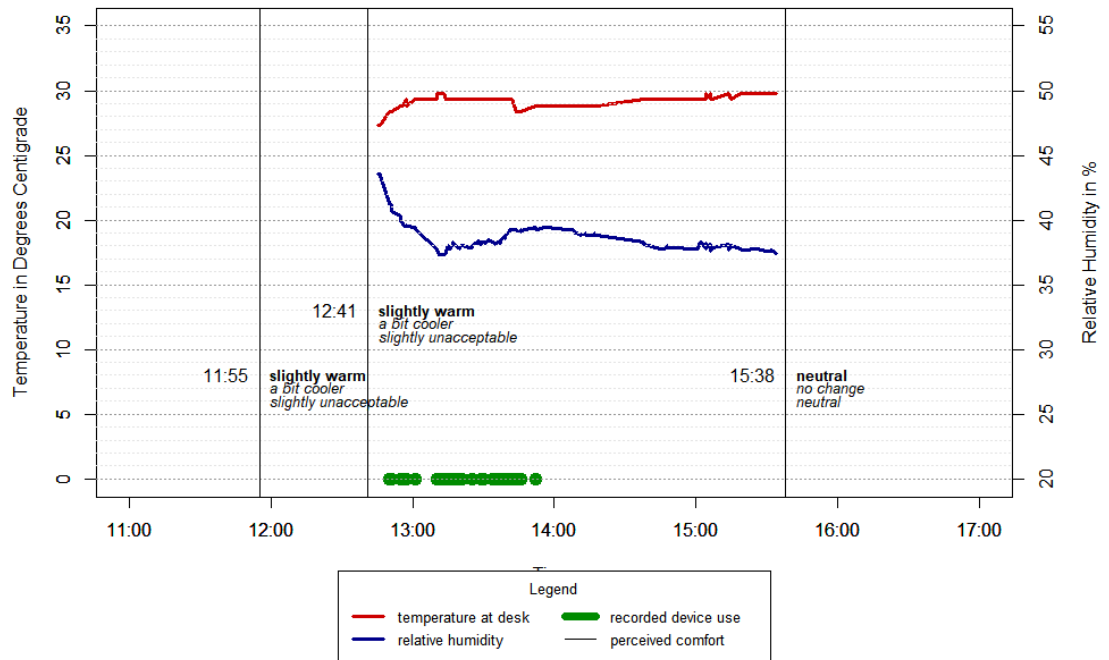


Outdoor Weather	Clear/sunny
Clothing	Trousers/long skirt, Tights/legging, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:19	Walking (outdoors)	Air movement too high/low Window(s) open, Lights on, Fan on	Room temperature	Prototype (on) I felt warm
12:10	Seated (passive)	Window(s) open, Lights on, Fan on		
14:07	Walking (outdoors)	Hot surrounding surfaces Window(s) open, Lights on, Fan on	Room temperature	Fan (up), Prototype (on)
16:03	Seated (active)	Hot surrounding surfaces Window(s) open, Lights on, Fan on	Room temperature	Prototype (off) I felt warm

Comments	(4) Put the prototype on my leg. I feel more warm after a while because the fabric. So I took it off.
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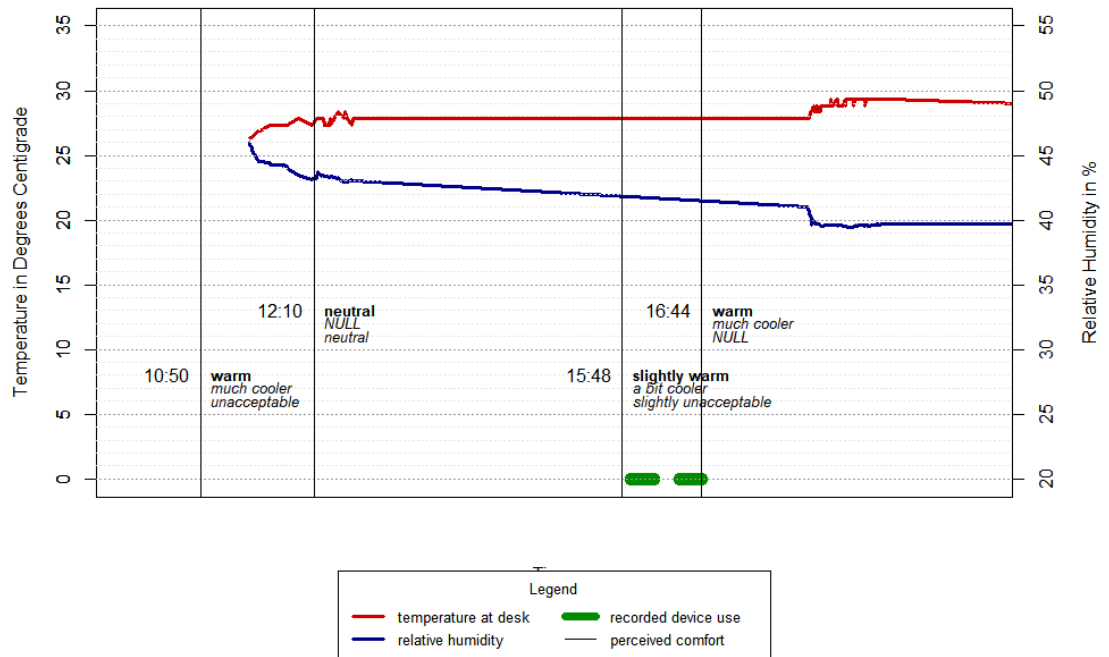
P5 – Day 3: 24/08/2016, Room C, Manual Control Mode



Outdoor Weather	Clear/sunny
Description	Short sleeved shirt/top, Dress, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:55	Walking (indoors)	Hot surrounding surfaces Window(s) open, Lights on		
12:41	Seated (active)	Hot surrounding surfaces Window(s) open, Lights on, Fan on	Room temperature	Prototype (on) I felt warm
15:38	Seated (active)	Hot surrounding surfaces Window(s) open, Lights on, Fan on	Room temperature	Prototype (on)

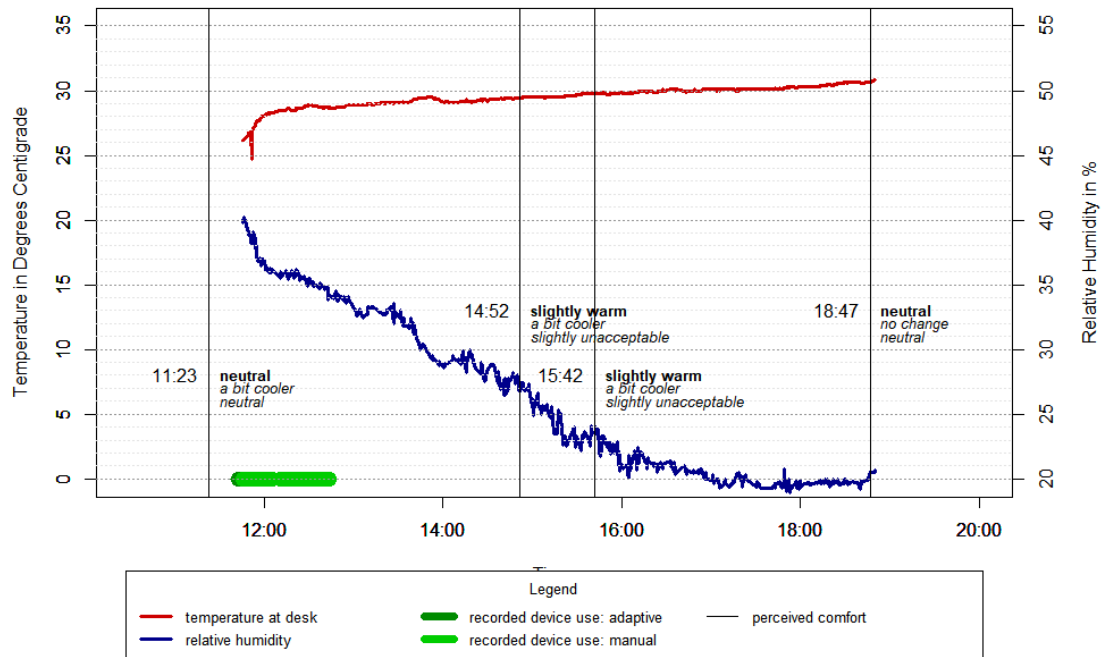
P5 – Day 4: 25/08/2016, Room C, Manual Control Mode



Outdoor Weather	Clear/sunny
Description	Short sleeved shirt/top, Shorts/short skirt, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:50		Hot surrounding surfaces Window(s) open, Lights on		Fan (up)
12:10		Window(s) open, Lights on, Fan on	Room temperature	
15:48		Window(s) open, Lights on, Fan on	Room temperature	Prototype (on)
16:44		Window(s) open, Lights on, Fan on		Prototype (off) I felt warm
Comments	(4) The band of prototype (I put it on my leg) make me feel really hot. And I can't feel the cool part on the prototype anymore.			

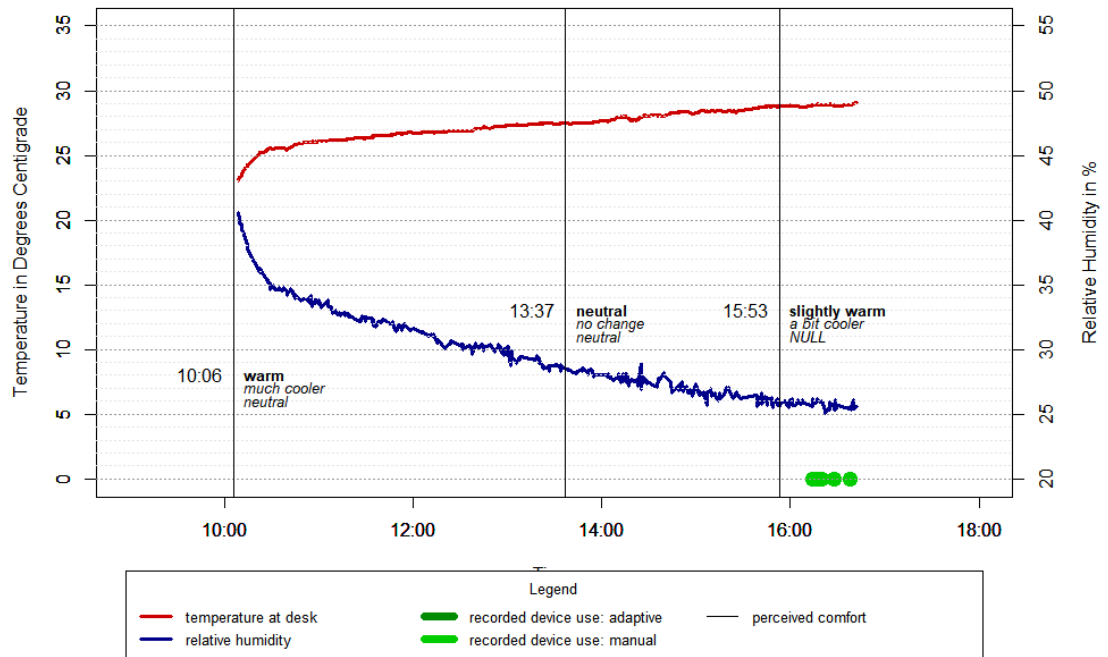
P5 – Day 5: 26/08/2016, Room C, Selective Control Mode



Outdoor Weather	Clear/sunny
Description	Short sleeved shirt/top, Trousers/long skirt, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:23	Seated (active)	Hot surrounding surfaces Door open, Window(s) open, Lights on		
14:52	Walking (indoors)	Door open, Window(s) open, Lights on	Hot	Fan (up)
15:42	Seated (active)	Door open, Window(s) open, Lights on, Fan on	Room temperature	
18:47	Seated (active)	Door open, Window(s) open, Lights on		Fan (down)

P5 – Day 6: 30/08/2016, Room C, Selective Control Mode

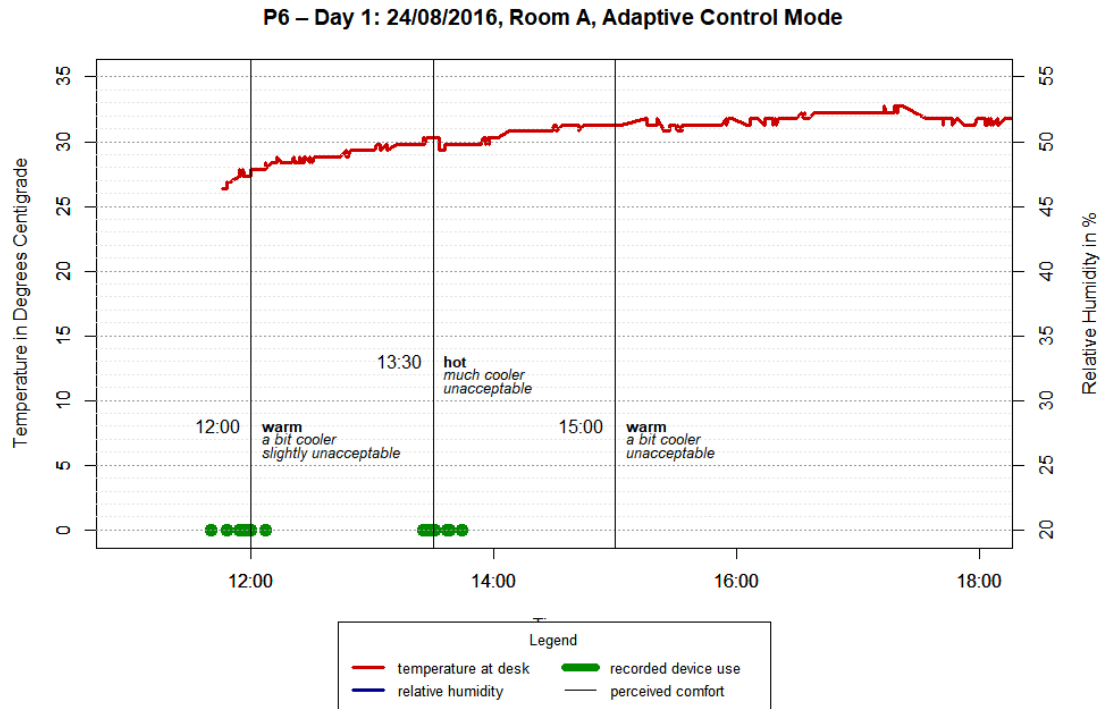


Outdoor Weather	Clear/sunny
Description	Short sleeved shirt/top, Tights/legging

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:06	Other (bicycle to school)	Window(s) open, Lights on		Item of clothing (off) I felt hot
13:37	Seated (active)	Window(s) open, Lights on		
15:53	Seated (active)	Hot surrounding surfaces Window(s) open, Lights on	Hot	Prototype (on) I felt warm

Participant P6

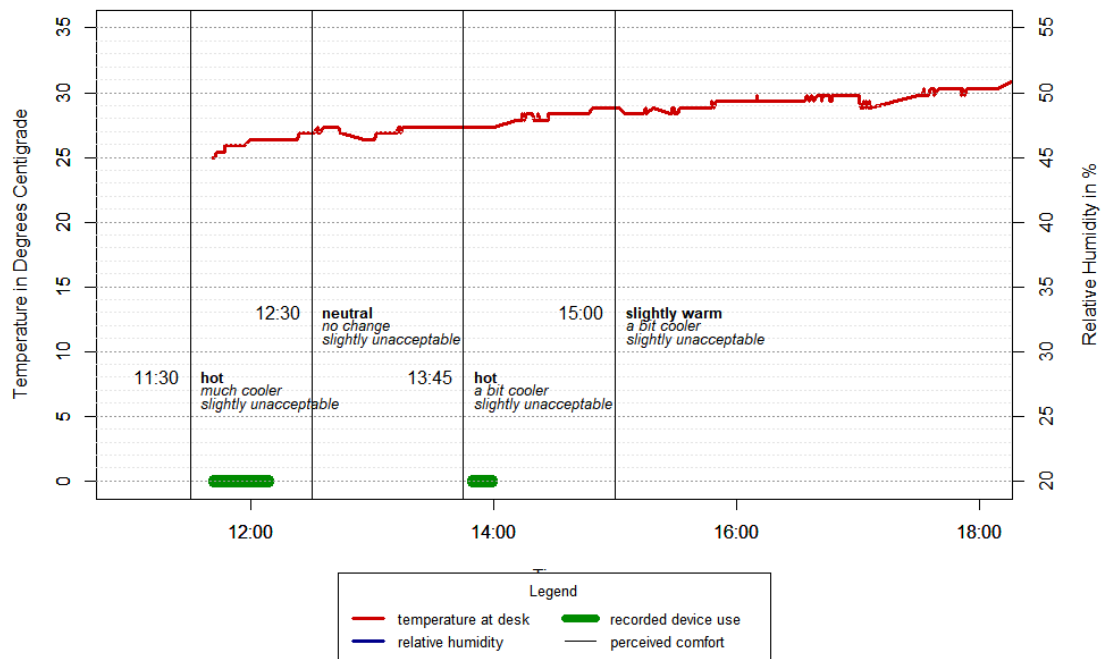
P6 – Ambient Control Mode – Day 1



Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:00	Walking (outdoors)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Cold	Prototype (on) I felt hot
13:30	Other (gym)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Cold	Prototype (on) I felt hot
15:00	Seated (active)	Air movement too high/low (too low - discussed face-to-face)	Room temperature	Prototype (on) I felt hot

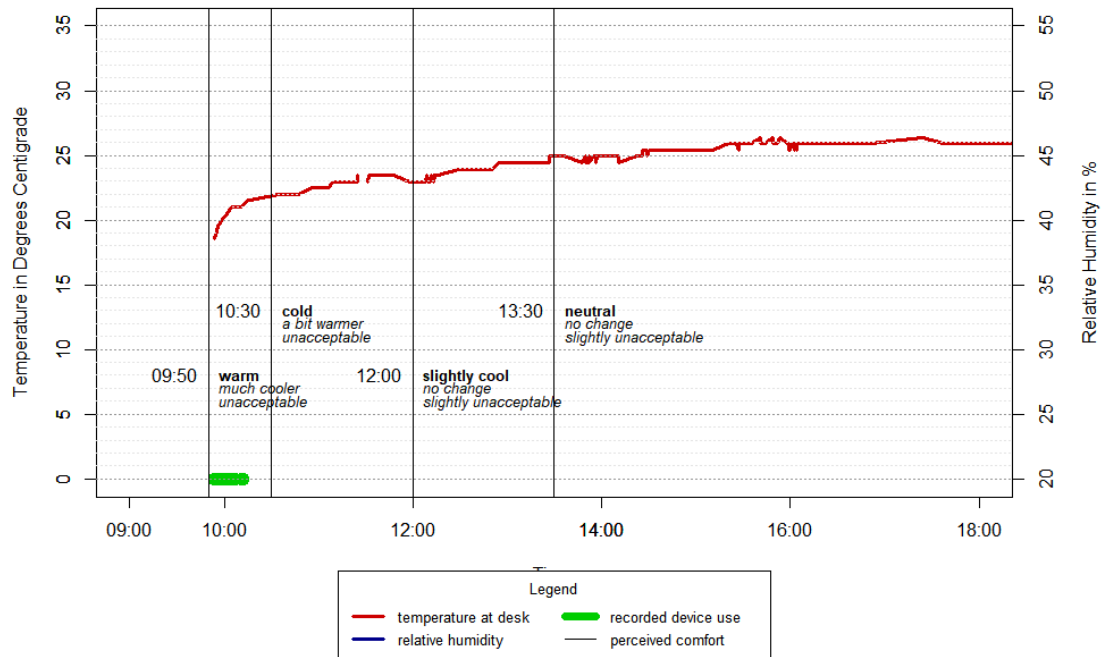
P6 – Day 2: 26/08/2016, Room A, Adaptive Control Mode



Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:30	Walking (outdoors)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	Prototype (on) I felt hot
12:30	Seated (active)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	Prototype (off) I felt cool
13:45	Other (gym)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	Prototype (on) I felt hot
15:00	Seated (active)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	

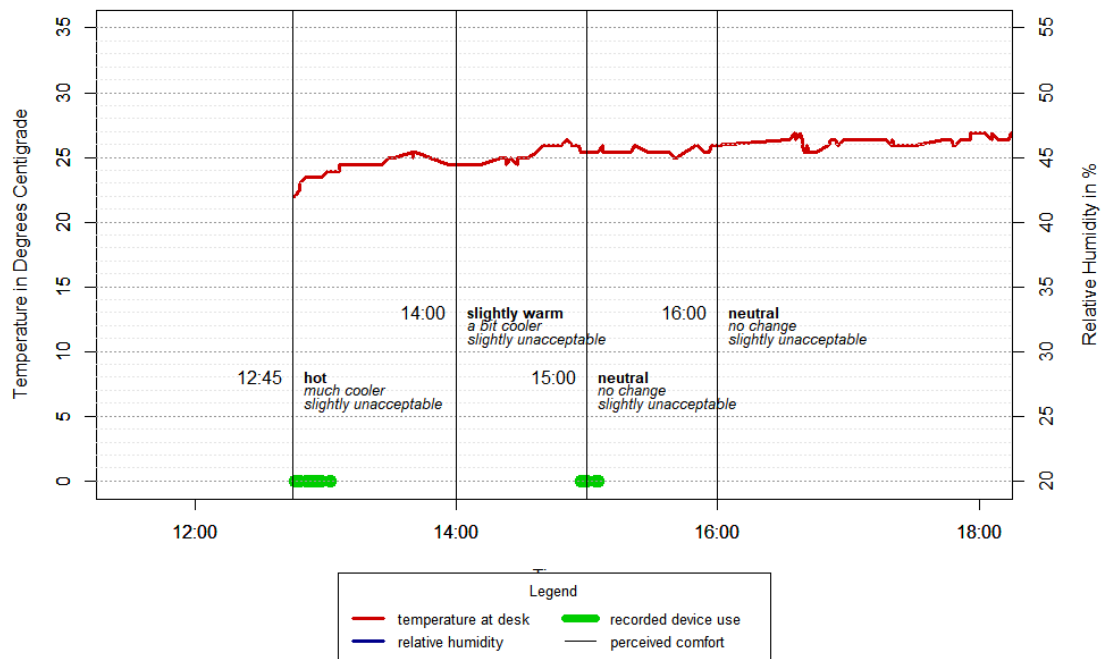
P6 – Day 3: 05/09/2016, Room A, Manual Control Mode



Outdoor Weather	Rainy
Clothing	Long sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:50	Walking (outdoors)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Cold	Prototype (on) I felt hot
10:30	Seated (active)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Cold	Prototype (off) I felt cool
12:00	Seated (active)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Cold	
13:30	Other (gym)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Cold	

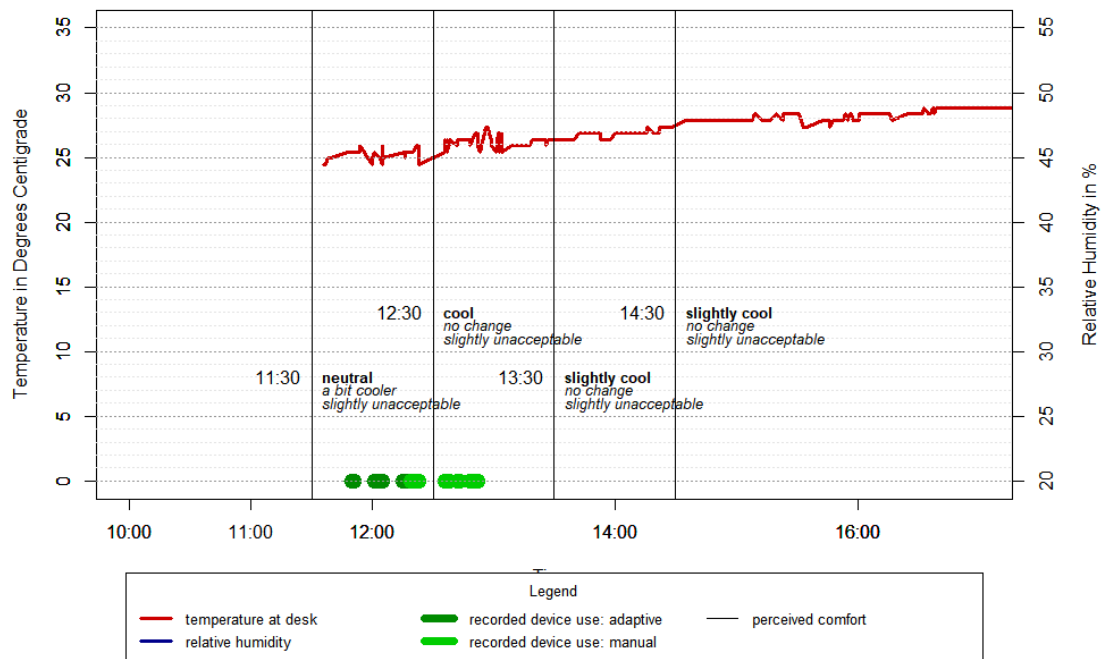
P6 – Day 4: 08/09/2016, Room A, Manual Control Mode



Outdoor Weather	Clear/sunny
Clothing	Long sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:45	Walking (outdoors)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	Prototype (on) I felt hot
14:00	Walking (outdoors)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	Item of clothing (on) I felt hot
15:00	Walking (outdoors)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	Item of clothing(off) I felt cool
16:00	Walking (outdoors)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	

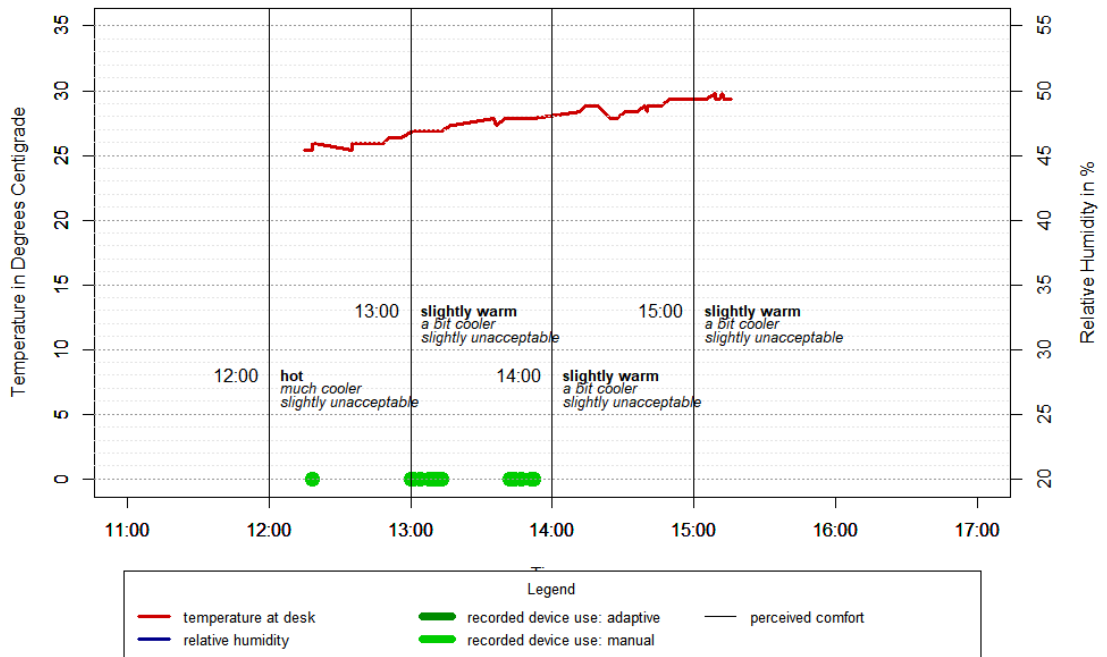
P6 – Day 5: 12/09/2016, Room A, Selective Control Mode



Outdoor Weather	Clear/sunny
Clothing	Long sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:30	Seated (passive)	Air movement too high/low (too low - discussed face-to-face) Window(s) open		Prototype (on) I felt warm
12:30	Seated (active)	Air movement too high/low (too low - discussed face-to-face) Window(s) open		
13:30	Seated (active)	Air movement too high/low (too low - discussed face-to-face) Window(s) open		Prototype (off) I felt cool
14:30	Seated (active)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	

P6 – Day 6: 15/09/2016, Room A, Selective Control Mode



Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:00	Walking (outdoors)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Cold	Prototype (on) I felt hot
13:00	Seated (active)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	Prototype (on) I felt warm
14:00	Seated (active)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	Prototype (on) I felt warm
15:00	Seated (active)	Air movement too high/low (too low - discussed face-to-face) Window(s) open	Room temperature	Prototype (off) Other (worried because it broke)

Participant P7

P7 – Manual Control Mode – Day 1

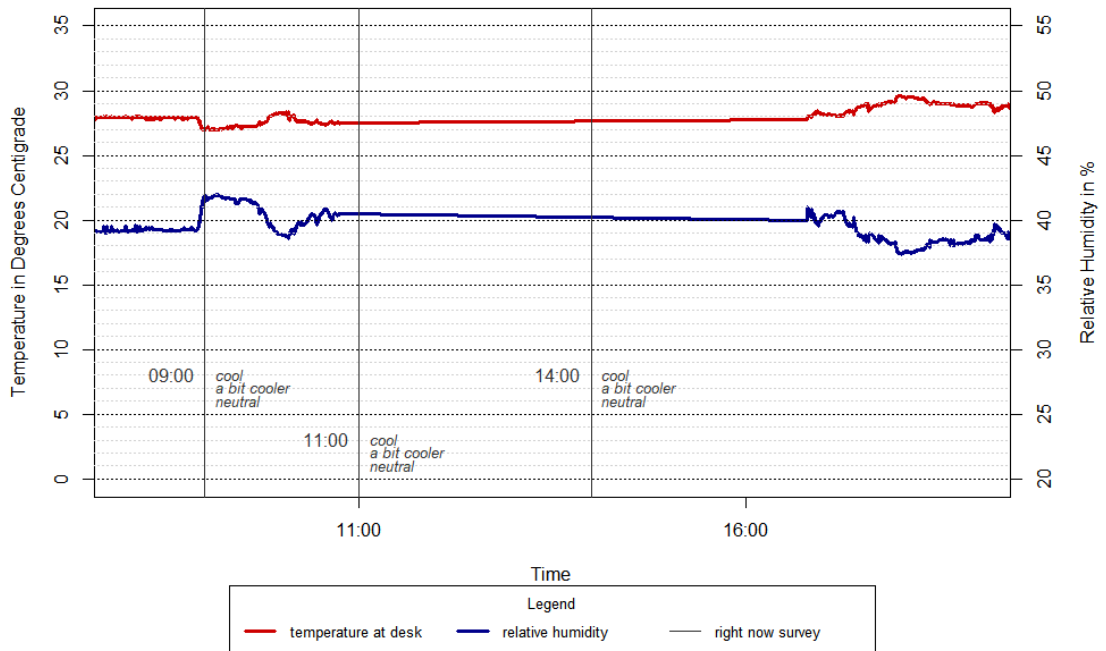
No data was recorded

Outdoor Weather	Clear/sunny
Clothing	Long sleeved shirt/top

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:00	Seated (active)	Air movement too high/low, Hot surrounding surfaces Lights on, Fan on	Room temperature	Fan (up), Prototype (on) I felt cool
11:00	Seated (active)	Air movement too high/low, Hot surrounding surfaces Lights on, Fan on	Room temperature	Fan (up), Prototype (on) I felt cool
14:00	Seated (active)	Air movement too high/low, Hot surrounding surfaces Lights on, Fan on	Room temperature	Fan (up), Prototype (on) I felt cool

Comment	
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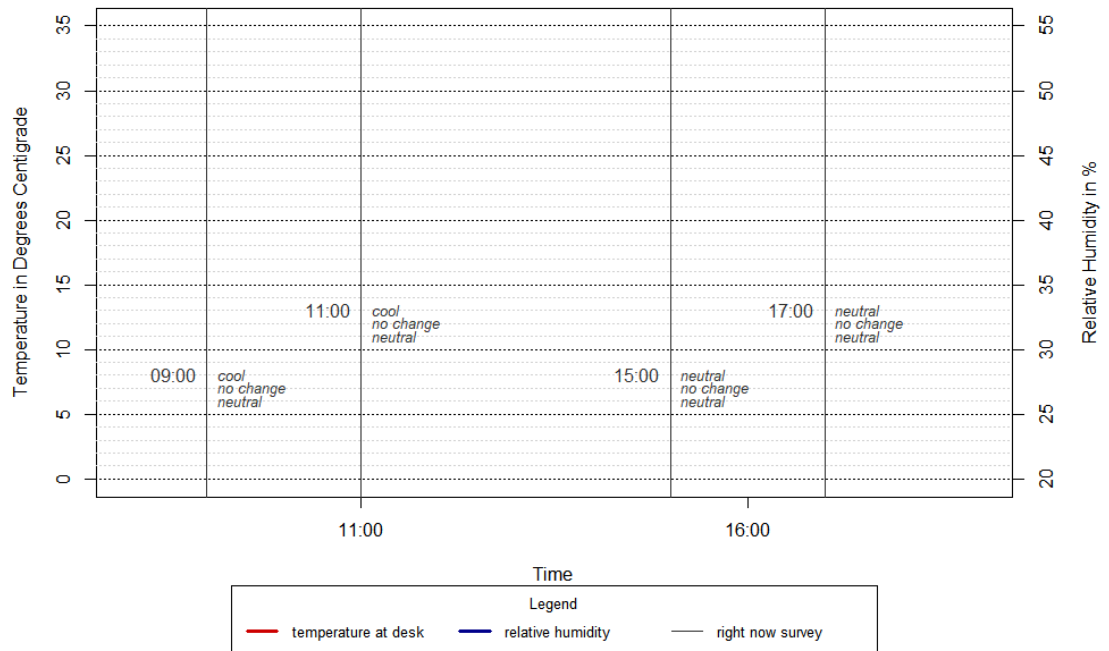
P7 – Day 2: 28/08/2016, Room H, Adaptive Control Mode



Outdoor Weather	Partly cloudy
Clothing	Long sleeved shirt/top

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
				I felt cool
09:00	Seated (active)	Hot surrounding surfaces Fan on	Room temperature	Fan (up), Prototype (on) I felt cool
11:00	Seated (active)	Hot surrounding surfaces Fan on	Room temperature	Fan (up), Prototype (on) I felt cool
14:00	Seated (active)	Hot surrounding surfaces Fan on	Room temperature	Fan (up), Prototype (on) I felt cool

P7 – Day 3: 12/09/2016, Room H, Adaptive Control Mode



Outdoor Weather	Clear/sunny
Clothing	Long sleeved shirt/top (am), Short sleeved shirt/top (pm)

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:00	Seated (passive)	Incoming sun Blinds/curtains down, Lights on	Room temperature	Fan (up) I felt warm
11:00	Seated (passive)	Incoming sun Blinds/curtains down, Lights on	Room temperature	Fan (up) I felt warm
13:00	Seated (active)	Incoming sun Blinds/curtains down, Lights on	Hot	Fan (up) I felt warm
17:00	Seated (active)	Incoming sun Blinds/curtains down, Lights on	Room temperature	Fan (up) I felt warm

P7 – Ambient Control Mode – Day 4

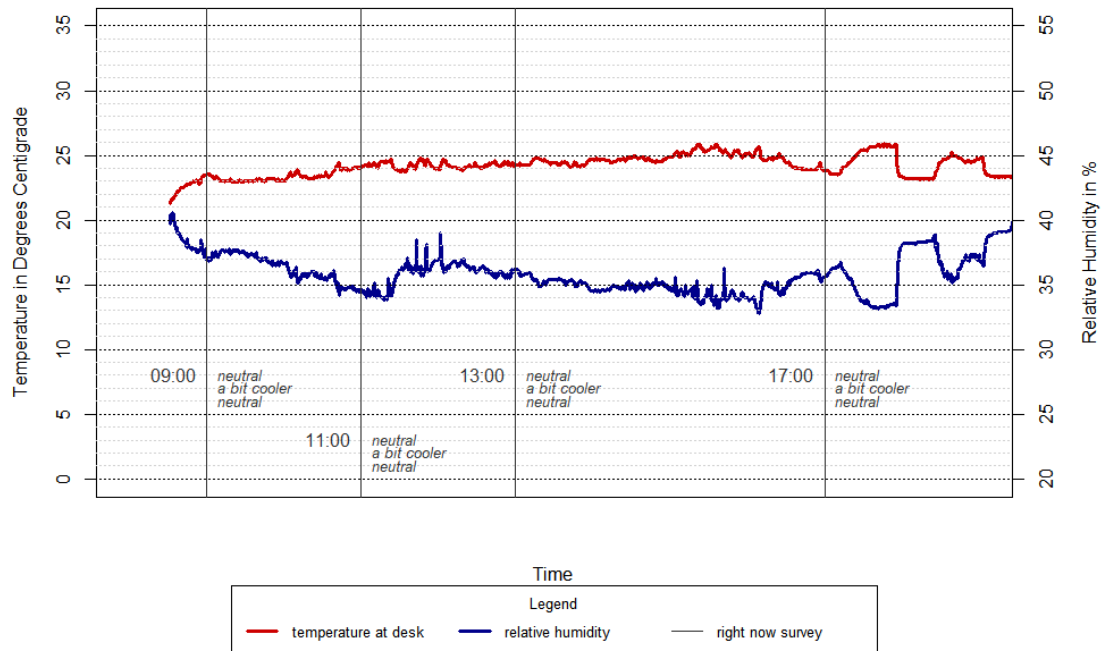
No data was recorded

Outdoor Weather	Clear/sunny
Clothing	Long sleeved shirt/top (am), Short sleeved shirt/top (pm)

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:00	Seated (passive)	Incoming sun, Drafts from windows/vents Blinds/curtains down, Lights on	Room temperature	Fan (up) I felt hot
11:00	Seated (passive)	Incoming sun, Drafts from windows/vents Blinds/curtains down, Lights on	Room temperature	Fan (up) I felt hot
13:00	Seated (active)	Incoming sun, Drafts from windows/vents Blinds/curtains down, Lights on	Hot	Fan (up) I felt hot
17:00	Seated (active)	Incoming sun, Drafts from windows/vents Blinds/curtains down, Lights on	Room temperature	Fan (up) I felt hot

P7 – Both Control Modes – Day 5

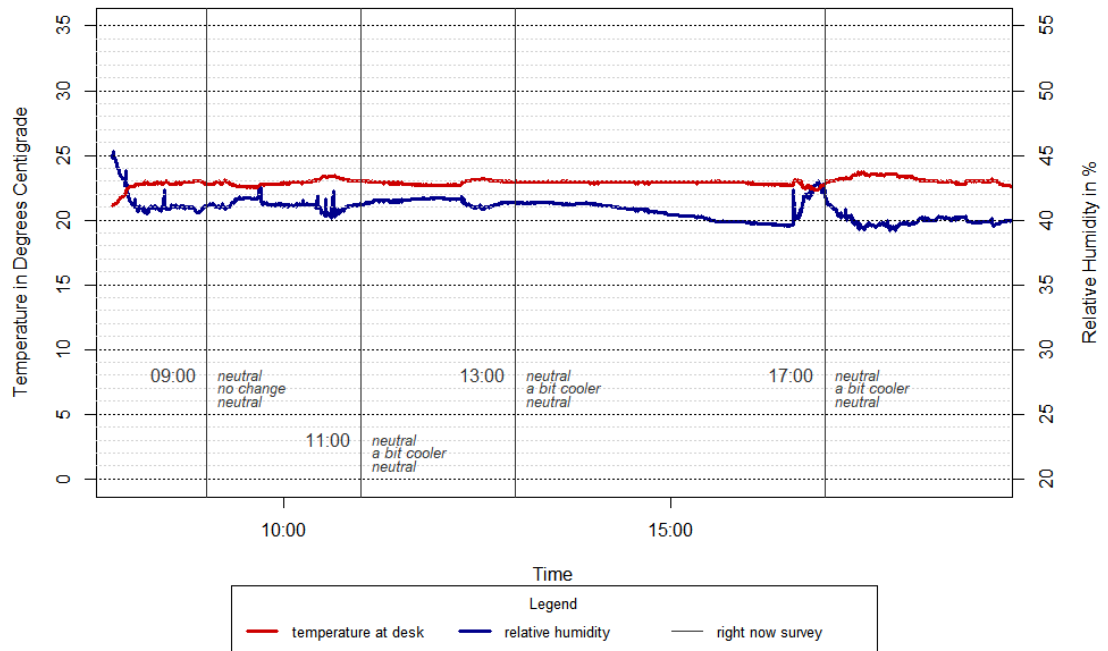
P7 – Day 5: 30/09/2016, Room H, Selective Control Mode



Outdoor Weather	Clear/sunny
Clothing	Long sleeved shirt/top

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:00	Standing (passive)	Drafts from windows/vents Blinds/curtains down, Lights on	Room temperature	I felt cool
11:00	Standing (passive)	Drafts from windows/vents Blinds/curtains down, Lights on		I felt cool
13:00	Standing (active)	Drafts from windows/vents Blinds/curtains down, Lights on		I felt cool
17:00	Standing (active)	Drafts from windows/vents Blinds/curtains down, Lights on		I felt cool

P7 – Day 6: 01/10/2016, Room H, Selective Control Mode

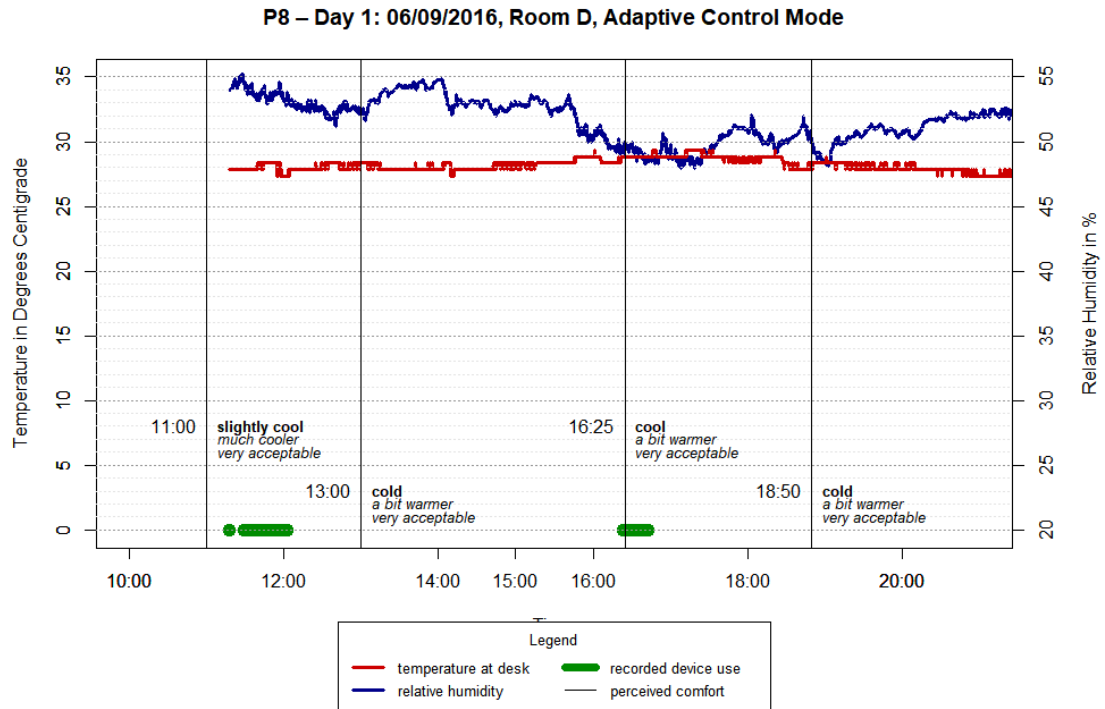


Outdoor Weather	Clear/sunny
Clothing	Long sleeved shirt/top

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:00	Standing (passive)	Cold surrounding surfaces Window(s) open, Lights on	Room temperature	I felt cool
11:00	Standing (passive)	Cold surrounding surfaces Blinds/curtains down, Lights on		I felt cool
13:00	Standing (active)	Cold surrounding surfaces Blinds/curtains down, Lights on		I felt cool
17:00	Standing (active)	Cold surrounding surfaces Blinds/curtains down, Lights on		I felt cool

Participant P8

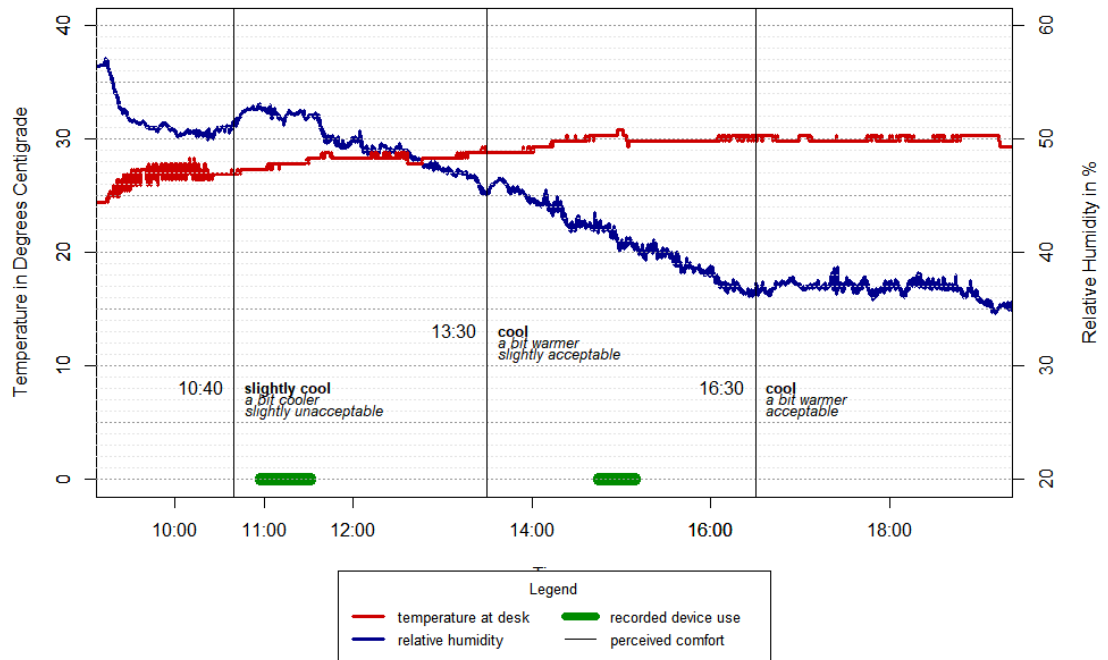
P8 – Ambient Control Mode – Day 1



Outdoor Weather	Cloudy/grey
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:00	Seated (active), Walking (indoors), Walking (outdoors)	Air movement too high/low (too low), Air condition provides not enough cooling, Other (not enough air) Door open, Window(s) open, Lights on	Cold	
13:00	Seated (active)	Air movement too high/low (too low) Door open, Window(s) open, Lights on	Room temperature	Prototype (off) Other (Discomfort)
16:25	Seated (active), Walking (indoors)	Air movement too high/low (too low) Door open, Window(s) open, Lights on	Room temperature	Prototype (on) Other (help Katia!)
18:50	Seated (active), Walking (indoors), Walking (outdoors)	Air movement too high/low (too low) Door open, Window(s) open, Lights on	Room temperature	Prototype (off) Other (no need for it)

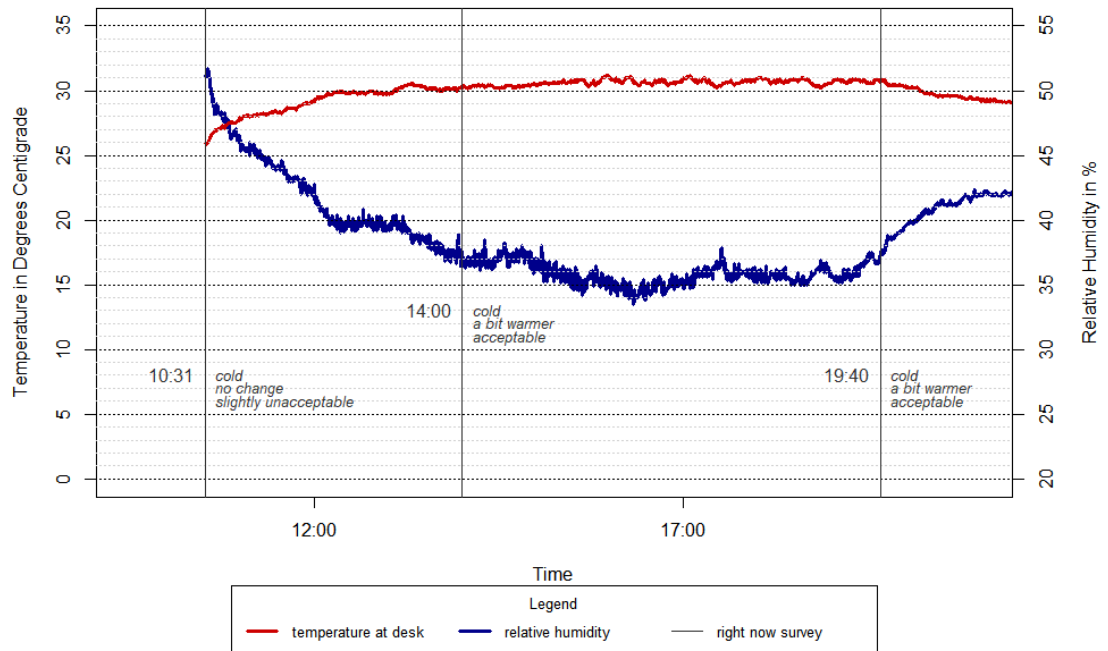
P8 – Day 2: 07/09/2016, Room D, Adaptive Control Mode



Outdoor Weather	Cloudy/grey (10:40), Partly cloudy (13:30), Clear/sunny (16:30)
Clothing	Short sleeved shirt/top, Shorts/short skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:40	Walking (indoors), Walking (outdoors)	Air movement too high/low (too low) Window(s) open, Lights on	Cold	
13:30	Seated (active)	Air movement too high/low (too low) Window(s) open, Lights on	Room temperature	
16:30	Seated (active)	Air movement too high/low (too low) Window(s) open, Lights on	Room temperature	

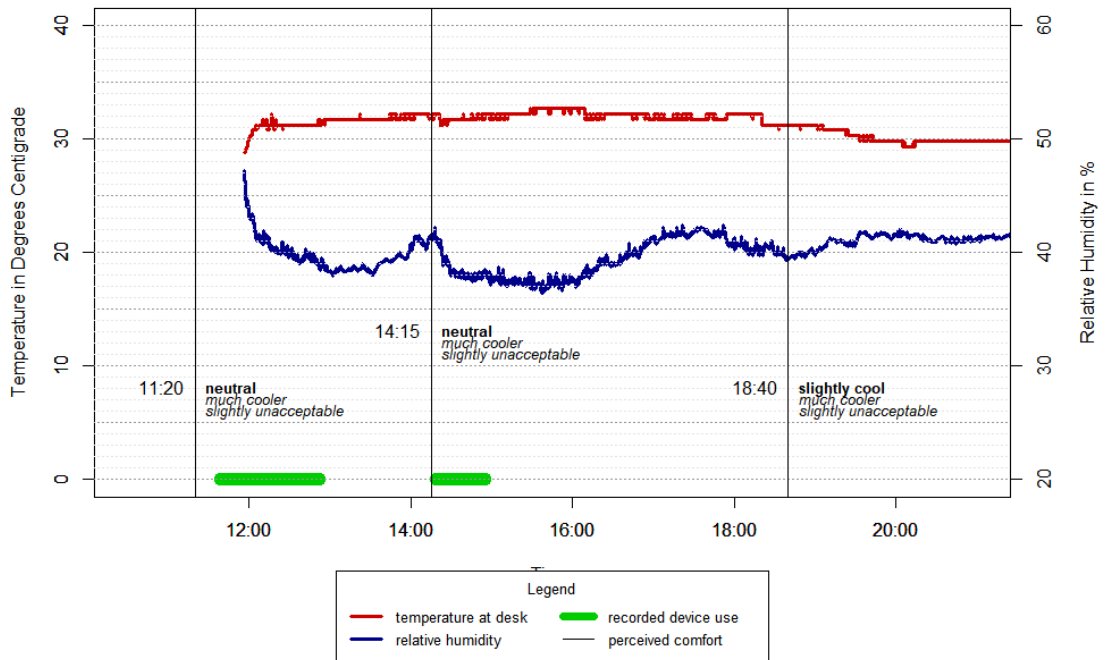
P8 – Day 3: 13/09/2016, Room D, Manual Control Mode



Outdoor Weather	Partly cloudy
Clothing	Short sleeved shirt/top, Shorts/short skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:31	Seated (active)	Air movement too high/low (too low) Window(s) open	Cold	
14:00	Seated (active)	Air movement too high/low (too low) Door open, Window(s) open	Room temperature	
19:40	Seated (active)	Air movement too high/low (too low) Window(s) open, Lights on	Cold	

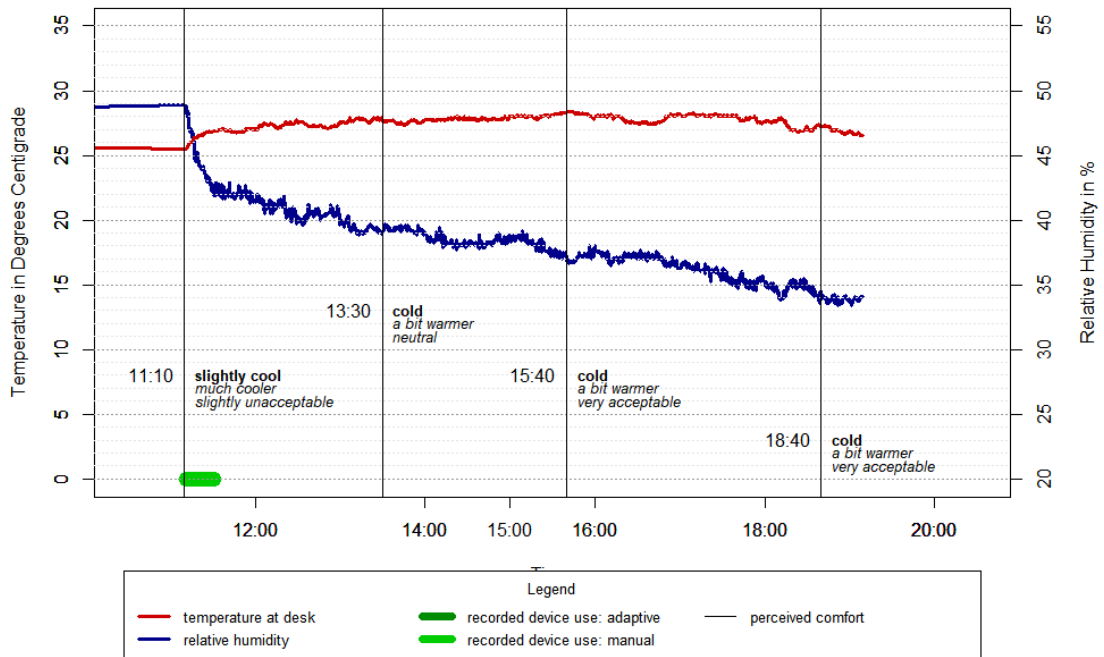
P8 – Day 4: 15/09/2016, Room D, Manual Control Mode



Outdoor Weather	Clear/sunny (am), Cloudy/grey (pm)
Clothing	Short sleeved shirt/top, Shorts/short skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:20	Walking (outdoors)	Air movement too high/low (too low) Door open, Window(s) open, Lights on	Cold	Prototype (on) I felt hot
14:15	Seated (passive), Walking (indoors)	Air movement too high/low, Air condition provides not enough cooling Door open, Window(s) open, Lights on	Cold	Prototype (on) I felt hot
18:40	Seated (active), Walking (indoors), Walking (outdoors)	Air movement too high/low (too low) Door open, Window(s) open, Lights on	Cold	

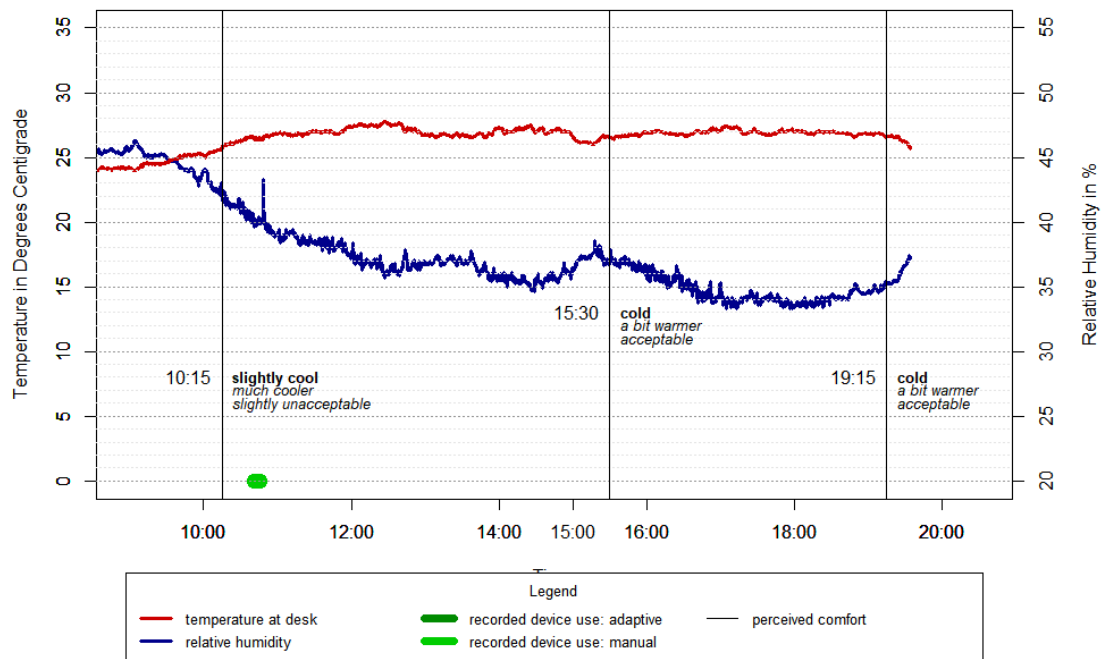
P8 – Day 5: 16/09/2016, Room D, Selective Control Mode



Outdoor Weather	Rainy (am), Cloudy/grey (pm)
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:10	Walking (outdoors)	Air movement too high/low (too low) Window(s) open, Lights on	Cold	Prototype (on) I felt hot
13:30	Standing (passive)	Air movement too high/low (too low) Window(s) open, Lights on	Cold	Prototype (off) Other (ran out of power)
15:40	Seated (active)	Air movement too high/low (too low) Window(s) open, Lights on	Room temperature	
18:40	Seated (active)	Air movement too high/low (too low) Window(s) open, Lights on	Cold	

P8 – Day 6: 21/09/2016, Room D, Selective Control Mode



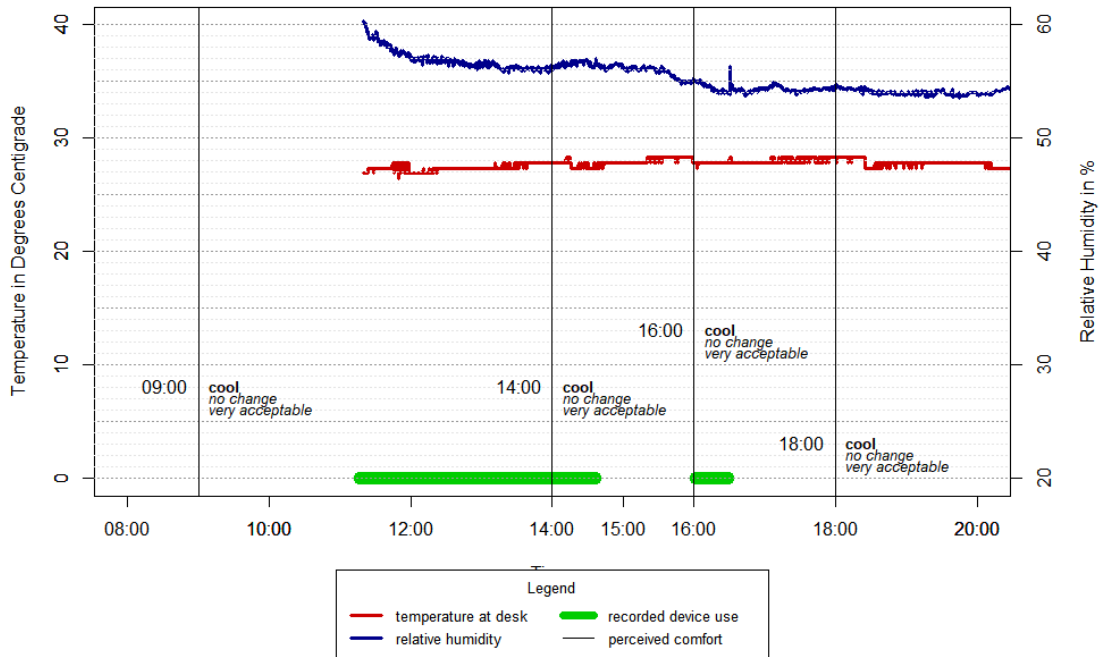
Outdoor Weather	Clear/sunny (am), Cloudy/grey (pm)
Clothing	Long sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:15	Walking (outdoors)	Air movement too high/low (too low) Lights on	Cold	Prototype (on), Window(s) (open) I felt warm
15:30	Standing (active), Walking (indoors)	Air movement too high/low (too low) Window(s) open, Lights on	Cold	
19:15	Standing (active), Walking (indoors)	Air movement too high/low (too low) Window(s) open, Lights on	Room temperature	

Participant P9

P9 – Manual Control Mode – Day 1

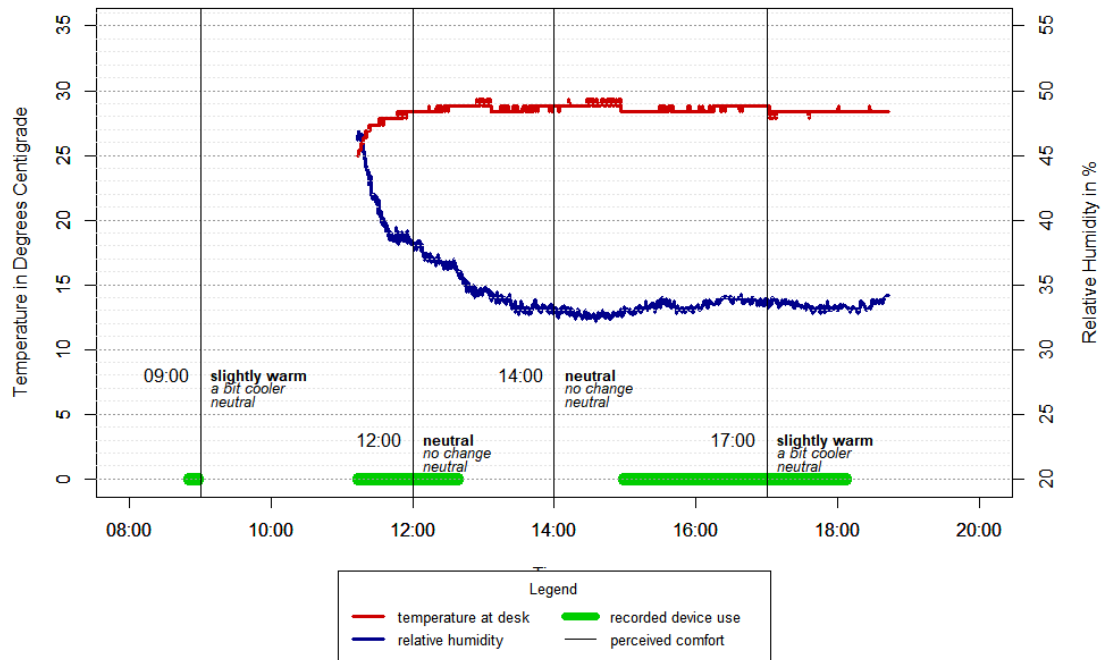
P9 – Day 1: 06/09/2016, Room D, Manual Control Mode



Outdoor Weather	Partly cloudy (am), Cloudy/grey (pm)
Clothing	Short sleeved shirt/top, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:00	Walking (outdoors)	Door open, Window(s) open, Lights on, Fan on		Fan (up) I felt warm
14:00	Seated (passive)	Door open, Window(s) open, Lights on	Room temperature	
16:00	Seated (passive)	Door open, Window(s) open, Lights on		
18:00	Seated (passive)	Door open, Window(s) open, Lights on		

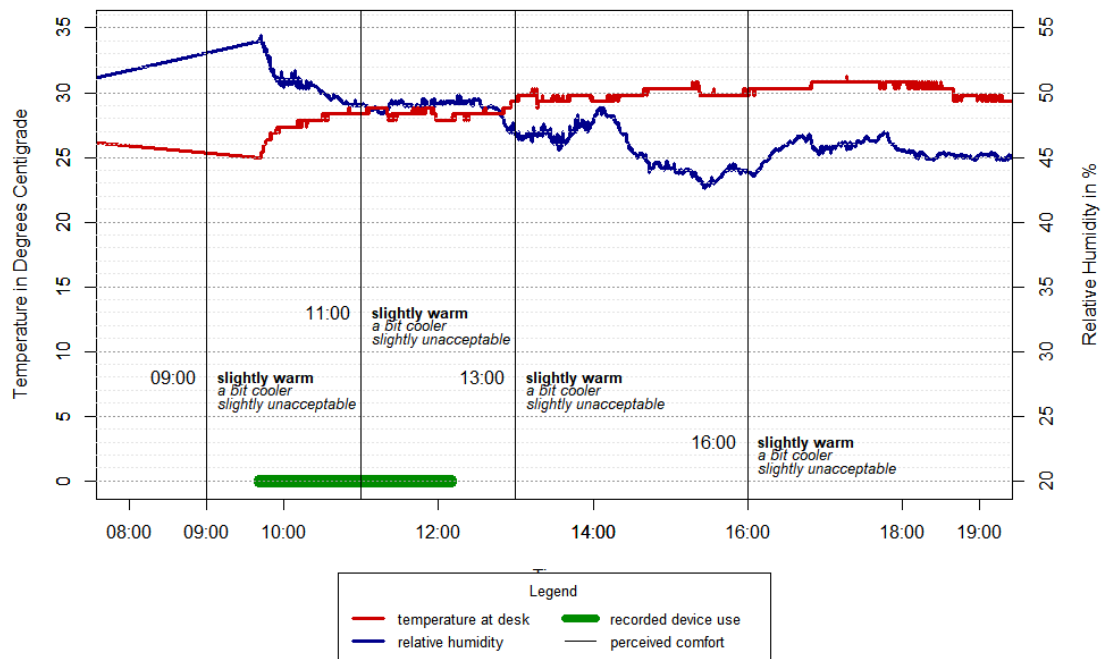
P9 – Day 2: 08/09/2016, Room D, Manual Control Mode



Outdoor Weather	Clear/sunny (9:00), Partly Cloudy
Clothing	Short sleeved shirt/top, Trousers/long skirt, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:00	Walking (outdoors)	Window(s) open, Lights on, Fan on		Fan (up) I felt warm
12:00	Seated (active)	Window(s) open, Lights on		
14:00	Seated (active)	Window(s) open, Lights on	Room temperature	
17:00	Seated (active)	Window(s) open, Lights on		

P9 – Day 3: 15/09/2016, Room D, Adaptive Control Mode

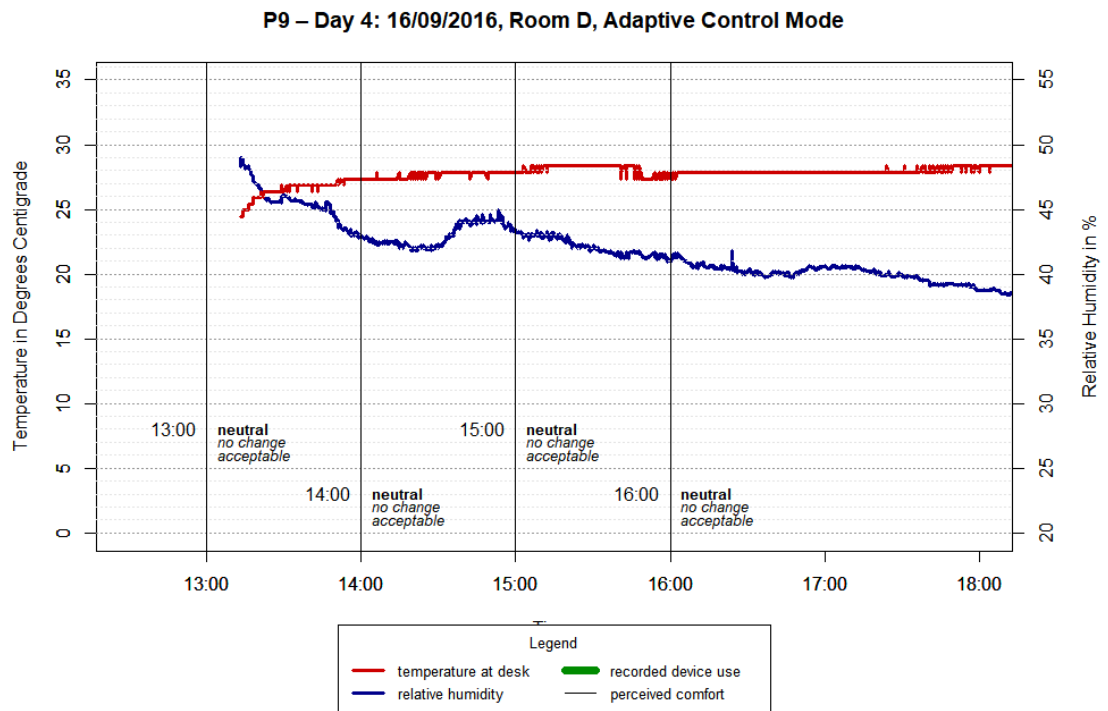


Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Shorts/short skirt, Sandals

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:00	Walking (outdoors)	Other (hot temperature) Door open, Window(s) open, Lights on, Fan on		Fan (up), Prototype (on) I felt warm
11:00	Seated (active)	Door open, Window(s) open, Lights on, Fan on		
13:00	Seated (active)	Door open, Window(s) open, Lights on, Fan on		Prototype (on) I felt warm
16:00	Seated (active)	Door open, Window(s) open, Lights on, Fan on		

Comments	(1) I don't really feel the difference between the modes of the prototype
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P9 – Ambient Control Mode – Day 4



Outdoor Weather	Drizzly (13:00), Cloudy/grey
Clothing	Short sleeved shirt/top, Trousers/long skirt, Shoes

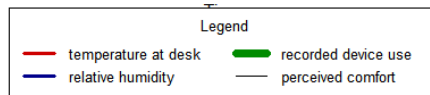
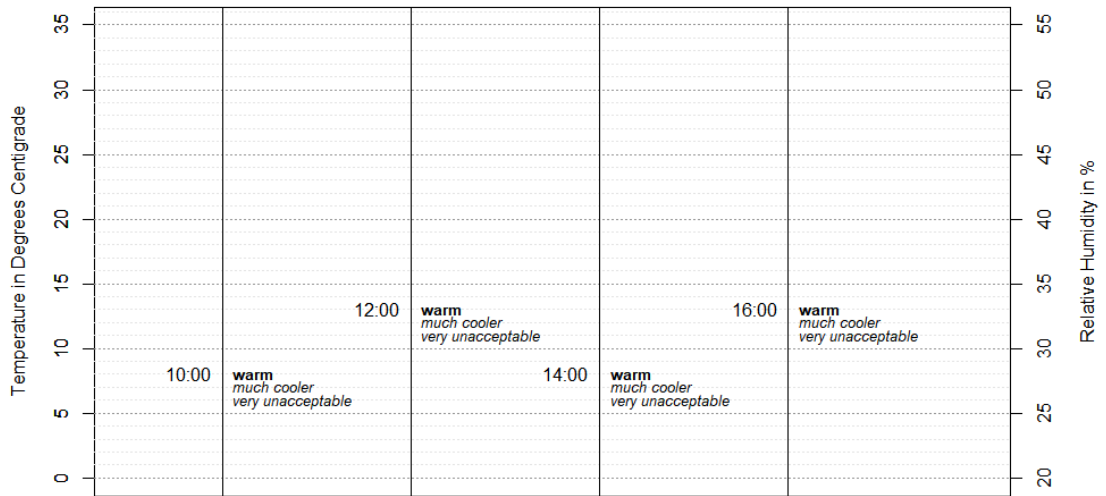
Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
13:00	Walking (outdoors)	Window(s) open, Lights on		
14:00	Seated (active)	Window(s) open, Lights on		
15:00	Seated (active)	Window(s) open, Lights on		
16:00	Seated (active)	Window(s) open, Lights on		

Experimented was terminated after day 4; no data was recorded for the last episode;

Participant P10

P10 – Ambient Control Mode – Day 1

P10 – Day 1: 15/09/2016, Room J, Adaptive Control Mode

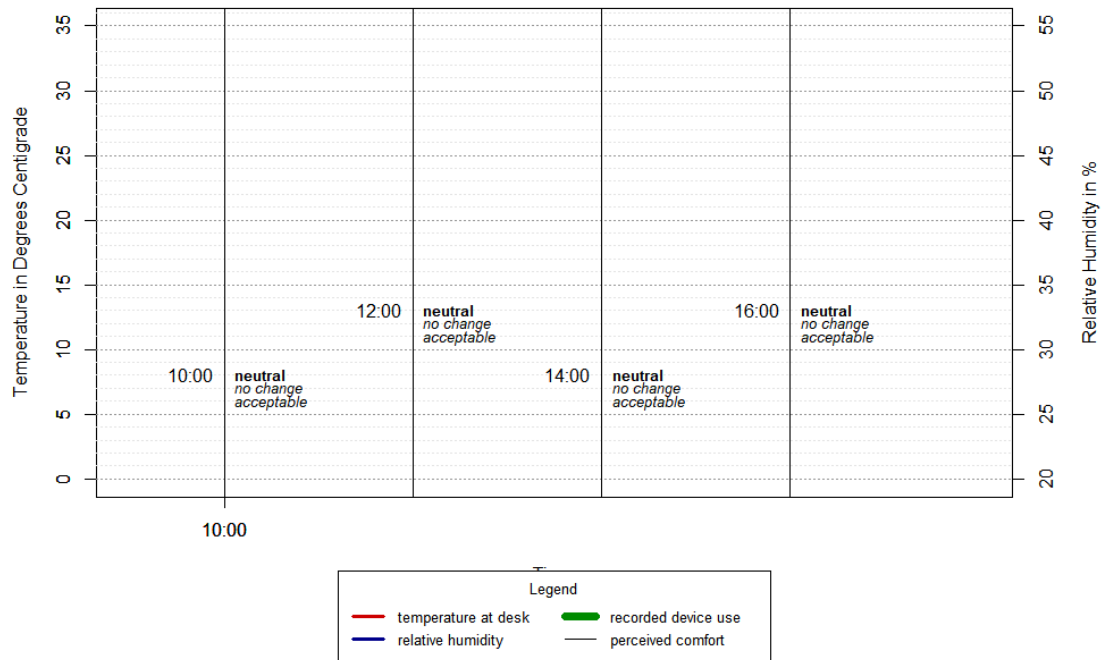


Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Trousers/long skirt, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:00	Seated (active)	Air movement too high/low, Incoming sun, Air condition provides not enough cooling, Personal device provides not enough cooling Door open, Window(s) open, Blinds/curtains down, Lights on, Fan on	Cold	Fan (up), Prototype (on), Window(s) (open) I felt hot
12:00	Seated (passive)	Air movement too high/low, Incoming sun, Air condition provides not enough cooling, Personal device provides not enough cooling Door open, Window(s) open, Blinds/curtains down, Lights on, Fan on	Cold	Fan (up), Window(s) (open) I felt hot
14:00	Seated (passive)	Air movement too high/low, Incoming sun, Air condition provides not enough cooling, Personal	Cold	Prototype (on), Window(s) (open) I felt hot

		device provides not enough cooling Door open, Window(s) open, Blinds/curtains down, Lights on, Fan on		
16:00	Seated (active)	Air movement too high/low, Incoming sun, Air condition provides not enough cooling, Personal device provides not enough cooling Door open, Window(s) open, Blinds/curtains down, Lights on, Fan on	Cold	Fan (up), Prototype (on), Window(s) (open) I felt hot

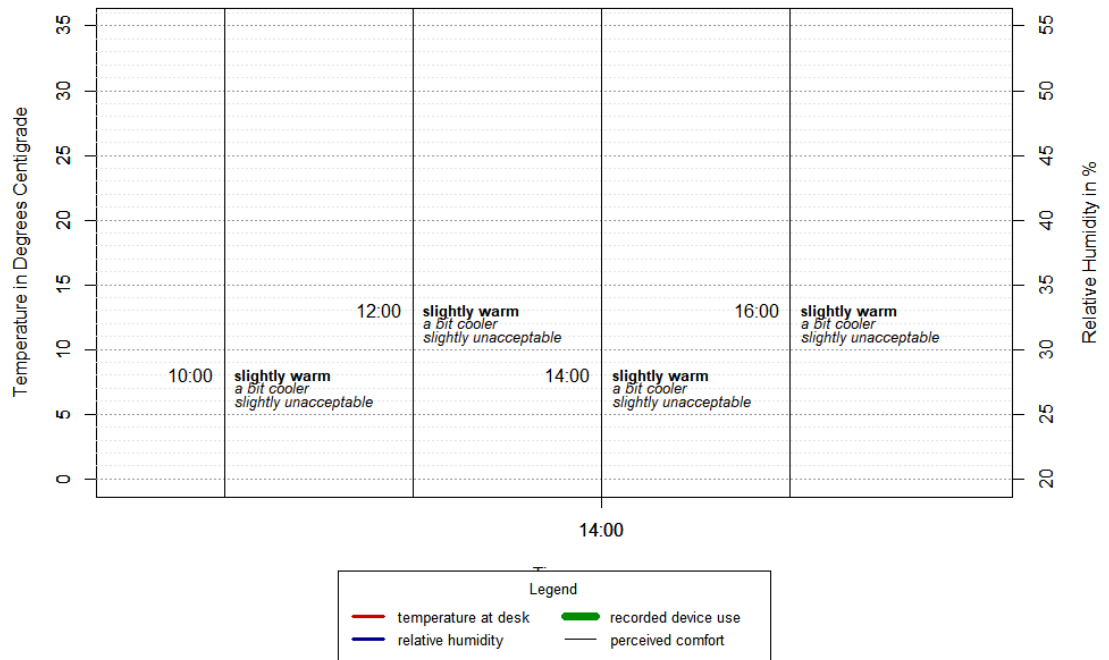
P10 – Day 2: 16/09/2016, Room J, Adaptive Control Mode



Outdoor Weather	Cloudy/grey
Clothing	Long sleeved shirt/top, Trousers/long skirt, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:00	Seated (active)	Window(s) open, Blinds/curtains down, Lights on	Cold	Window(s) (open)
12:00	Walking (outdoors)	Window(s) open, Blinds/curtains down, Lights on	Cold	Window(s) (open)
14:00	Seated (active)	Window(s) open, Blinds/curtains down, Lights on	Cold	Window(s) (open)
16:00	Seated (passive)	Window(s) open, Blinds/curtains down, Lights on	Cold	Window(s) (open)

P10 – Day 3: 20/09/2016, Room J, Manual Control Mode

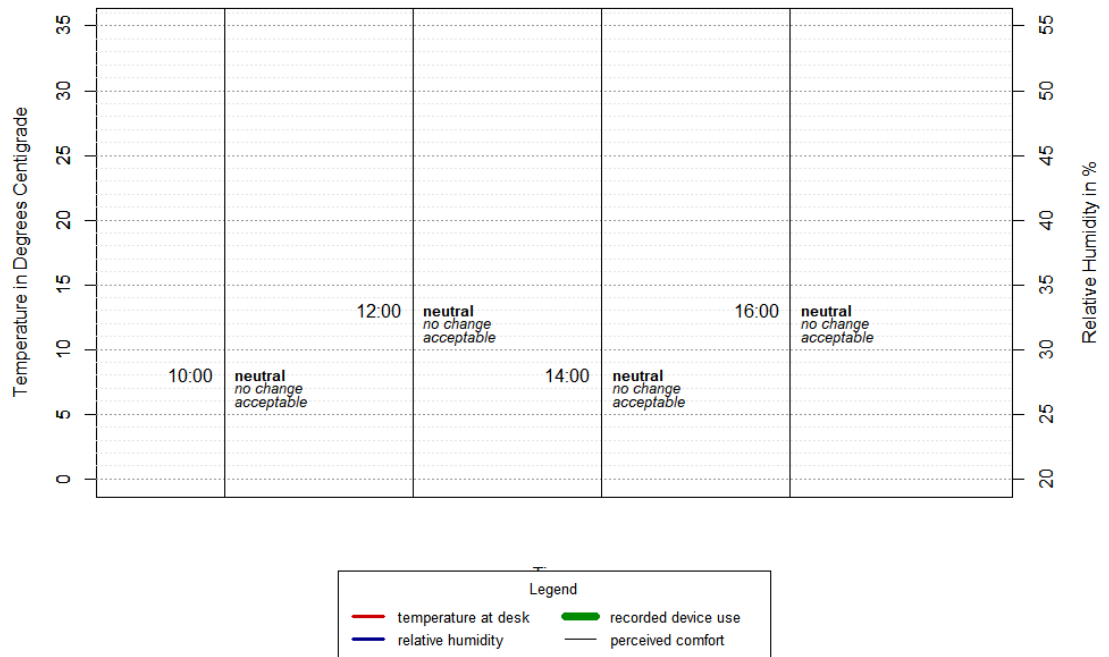


Outdoor Weather	Clear/sunny
Clothing	Short sleeved shirt/top, Trousers/long skirt, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:00	Seated (passive)	Incoming sun Window(s) open, Lights on	Cold	
12:00	Seated (passive)	Incoming sun Window(s) open, Lights on, Fan on	Cold	
14:00	Seated (passive), Seated (active)	Incoming sun Window(s) open, Lights on	Cold	
16:00	Seated (passive), Seated (active)	Incoming sun Window(s) open, Lights on	Cold	

P10 – Ambient Control Mode – Day 4

P10 – Day 4: 21/09/2016, Room J, Manual Control Mode



Outdoor Weather	Cloudy/grey
Clothing	Short sleeved shirt/top, Trousers/long skirt, Shoes

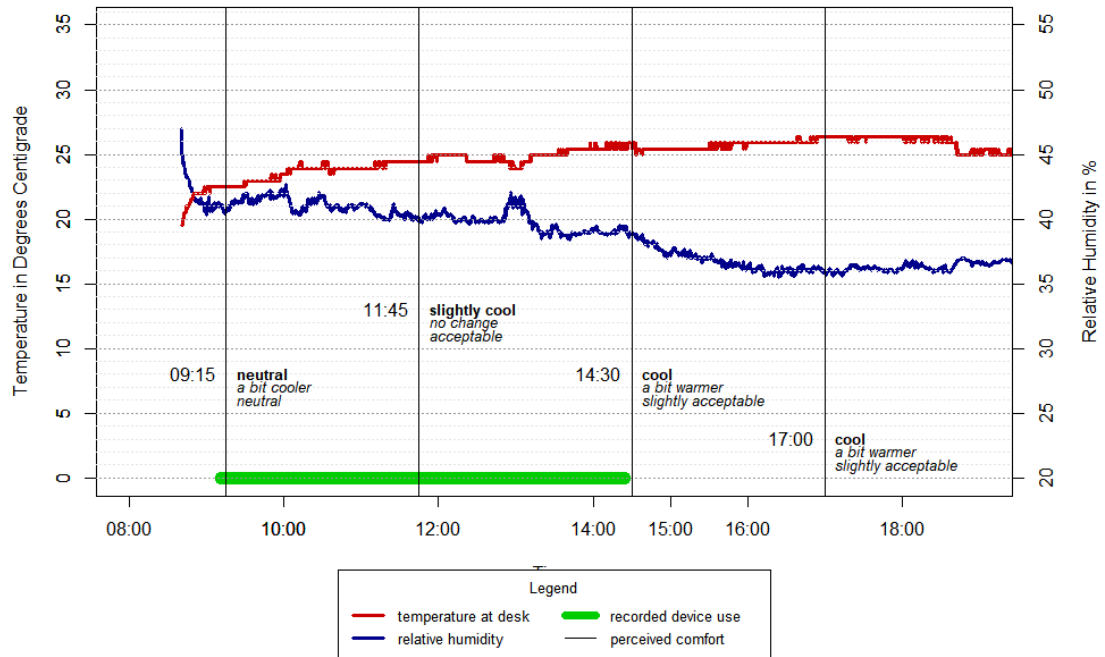
Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
10:00	Seated (active)	Air movement too high/low Lights on	Cold	
12:00	Seated (active)	Air movement too high/low Lights on	Cold	
14:00	Seated (active)	Air movement too high/low Lights on	Cold	
16:00	Seated (active)	Air movement too high/low Lights on	Cold	
Comments	not hot enough to use prototype a lot.			

Participant P10 terminated the experiment after day 4; no data recorded for last episode;

Participant P11

P11 – Manual Control Mode – Day 1

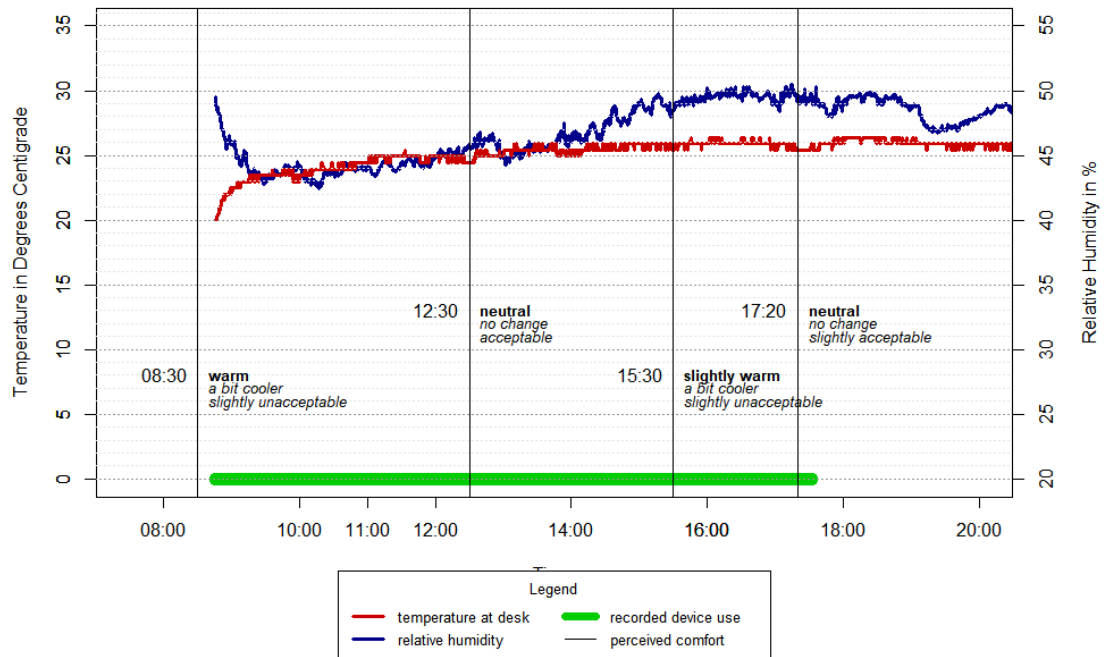
P11 – Day 1: 26/09/2016, Room J, Manual Control Mode



Outdoor Weather	Cloudy/grey (9:15), Partly cloudy
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks, Boots

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:15	Walking (outdoors)	Air movement too high/low Lights on		Item of clothing (off), Prototype (on), Window(s) (close) I felt hot
11:45	Seated (active)	Lights on	Cold	Item of clothing (on), Prototype (on), Window(s) (close) I felt cool
14:30	Seated (active)	Air condition provides too much cooling Lights on		
17:00	Seated (active)	Air condition provides too much cooling Lights on	Cold	

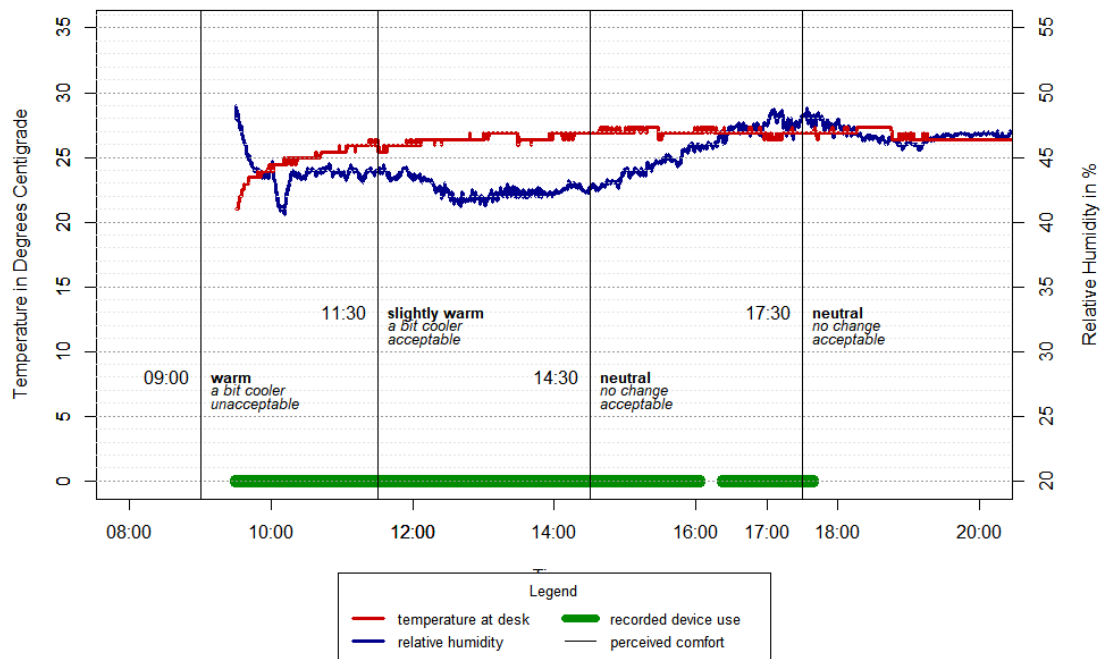
P11 – Day 2: 27/09/2016, Room J, Manual Control Mode



Outdoor Weather	Partly cloudy (08:30), Cloudy/grey (12:30, 15:30), Drizzly (17:20)
Clothing	Short sleeved shirt/top, Trousers/long skirt, Jumper/Cardigan/Sweatshirt, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
08:30	Walking (outdoors)	Air movement too high/low, Hot surrounding surfaces Lights on		Item of clothing (off), Prototype (on) I felt hot
12:30	Seated (active)	Lights on	Cold	
15:30	Walking (indoors)	Air movement too high/low, Hot surrounding surfaces Lights on	Hot	Item of clothing (off) I felt hot
17:20	Standing (active)	Air movement too high/low, Hot surrounding surfaces Lights on		Item of clothing (on) I felt cool

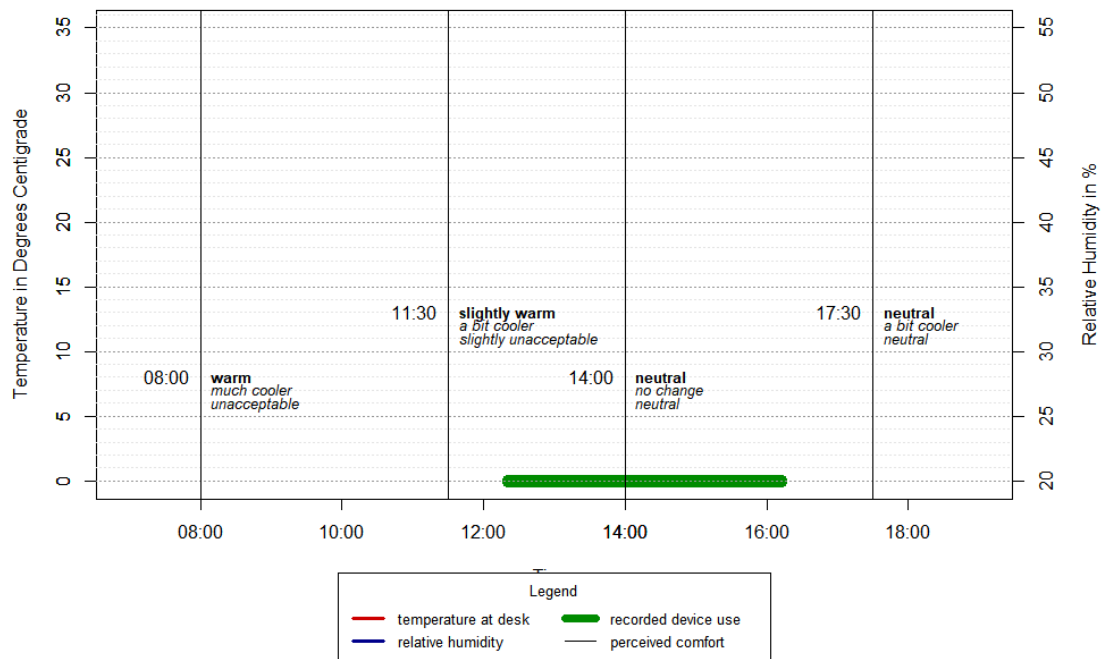
P11 – Day 3: 28/09/2016, Room J, Adaptive Control Mode



Outdoor Weather	Clear/sunny (am), Partly cloudy (pm)
Clothing	Dress, Tights/legging, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:00	Walking (indoors)	Air movement too high/low, Incoming sun, Hot surrounding surfaces Blinds/curtains down, Lights on		Item of clothing (off), Prototype (on) I felt hot
11:30	Standing (active)	Blinds/curtains down, Lights on		
14:30	Standing (active)	Lights on	Hot	blinds (close) I felt cool
17:30	Standing (active)	Lights on		Window(s) (open) I felt cool

P11 – Day 4: 30/09/2016, Room J, Adaptive Control Mode



Outdoor Weather	Clear/sunny, Partly cloudy (17:30)
Clothing	Dress, Jumper/Cardigan/Sweatshirt, Jacket, Tights/legging, Shoes

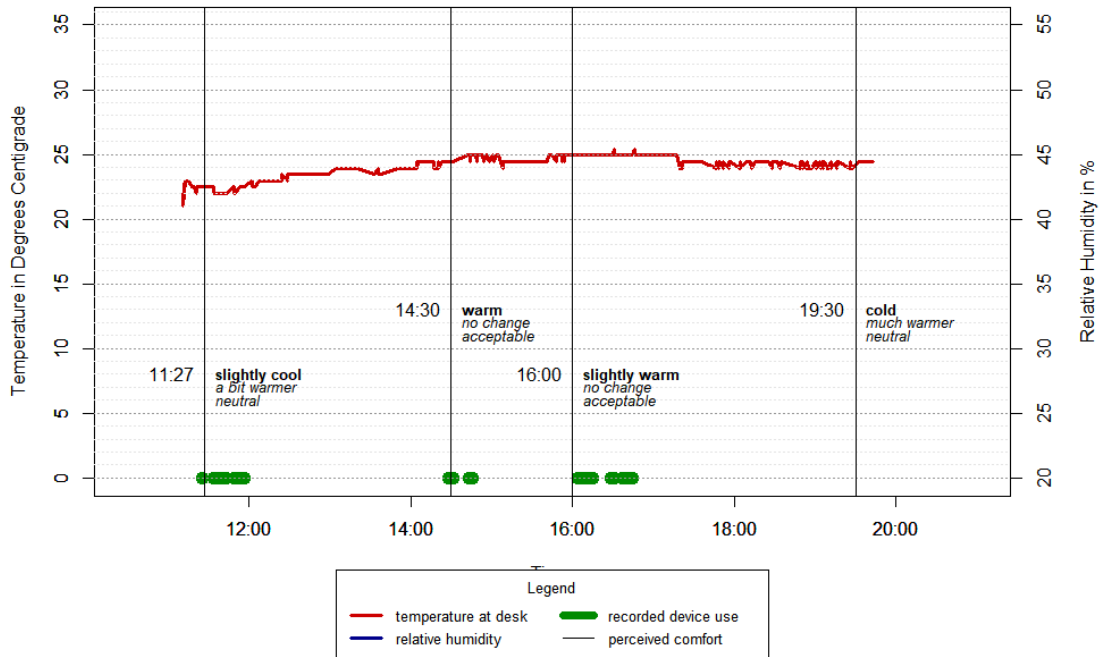
Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
08:00	Walking (outdoors)	Air movement too high/low, Incoming sun, Hot surrounding surfaces Blinds/curtains down, Lights on		Item of clothing (off), Prototype (on) I felt hot
11:30	Walking (indoors)	Air movement too high/low, Incoming sun, Hot surrounding surfaces Blinds/curtains down, Lights on	Cold	Item of clothing (off), Prototype (on) I felt warm
14:00	Standing (active)	Blinds/curtains down, Lights on	Cold	
17:30	Seated (active)	Blinds/curtains down, Lights on		

The experiment was terminated after day 4; no data recorded for last episode;

Participant P12

P12 – Manual Control Mode – Day 1

P12 – Day 1: 04/10/2016, Room G, Adaptive Control Mode

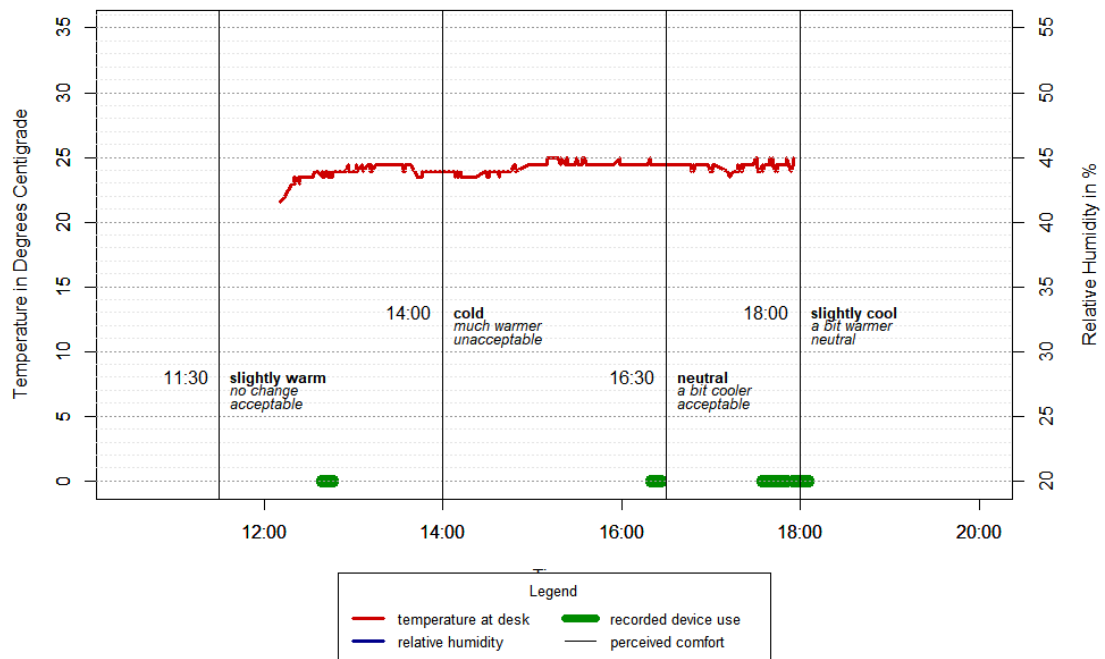


Outdoor Weather	Partly cloudy (11:27), Clear/sunny (14:30, 16:00), Other (dark, 19:30)
Clothing	Long sleeved shirt/top, Vest/sleeveless top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:27	Seated (active)	Air condition provides too much cooling Door open, Window(s) open, Lights on, Air condition on	Cold	Window(s) open "can't close it :("
14:30	Walking (outdoors)	Window(s) open, Lights on, Air condition on	Cold	Window(s) open
16:00	Walking (indoors)	Air movement too high/low (too high) Door open, Window(s) open, Lights on, Air condition on	Room temperature	Window(s) open
19:30	Seated (active)	Drafts from windows/vents Window(s) open, Lights on		Window(s) open

Comments	Hadn't realised how much temperature/thermal comfort changed over the course of the day just sitting in the same room, interesting!
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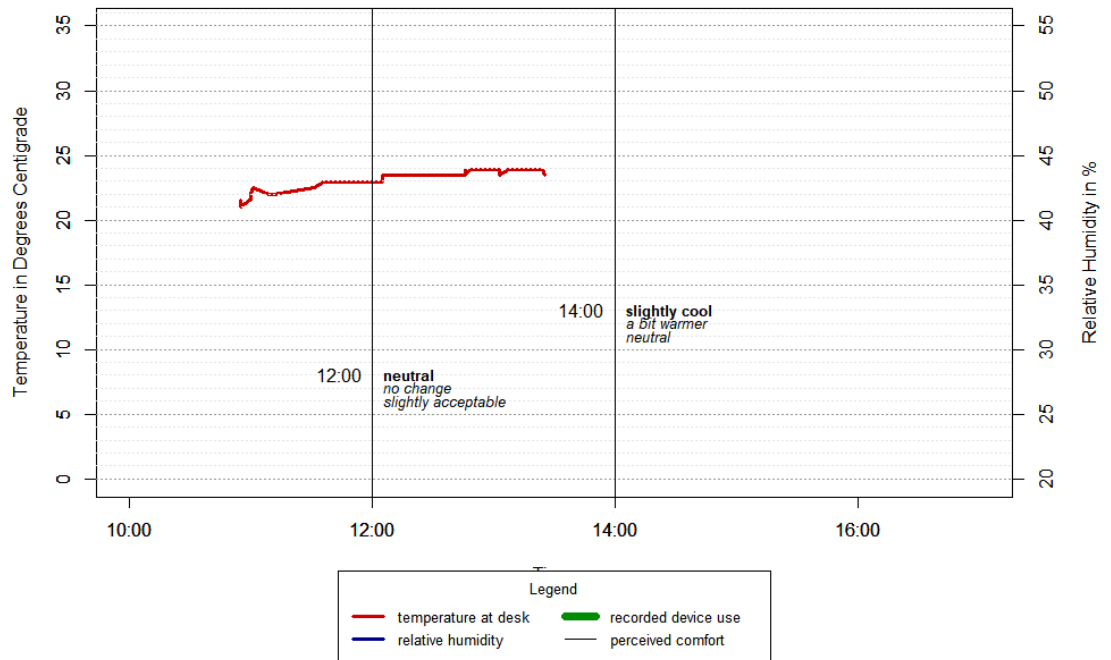
P12 – Day 2: 05/10/2016, Room G, Adaptive Control Mode



Outdoor Weather	Partly cloudy (am), Clear/sunny (pm)
Clothing	Short sleeved shirt/top, Vest/sleeveless top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
11:30	Walking (outdoors)	Window(s) open, Lights on, Air condition on		
14:00	Seated (passive)	Air movement too high/low, Drafts from windows/vents, Air condition provides too much cooling, Personal device provides too much cooling Door open, Window(s) open, Lights on, Air condition on		Item of clothing (on) I felt cold
16:30	Seated (passive)	Door open, Window(s) open, Lights on, Air condition on	Hot	
18:00	Seated (active)	Personal device provides too much cooling Door open, Window(s) open, Lights on, Air condition on	Room temperature	

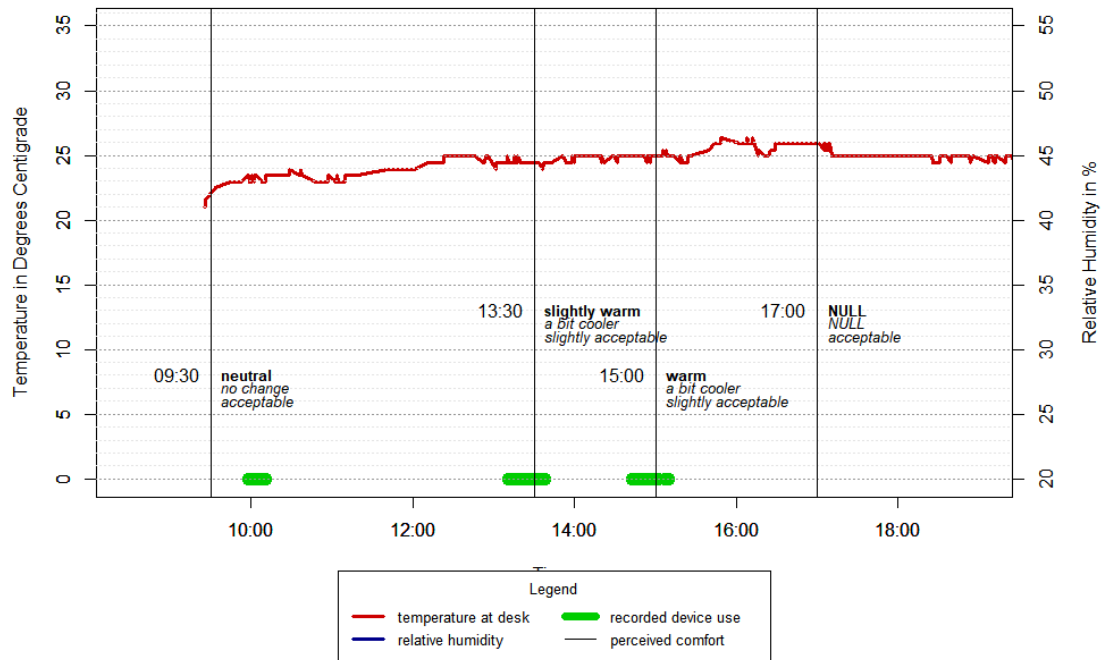
P12 – Day 3: 07/10/2016, Room G, Manual Control Mode



Outdoor Weather	Cloudy/grey
Clothing	Long sleeved shirt/top, Jumper/Cardigan/Sweatshirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:00	Walking (outdoors)	Door open, Window(s) open, Lights on, Room heating/heater on		
14:00	Seated (active)	Air movement too high/low Door open, Window(s) open, Lights on, Room heating/heater on	Room temperature	

P12 – Day 4: 20/10/2016, Room G, Manual Control Mode



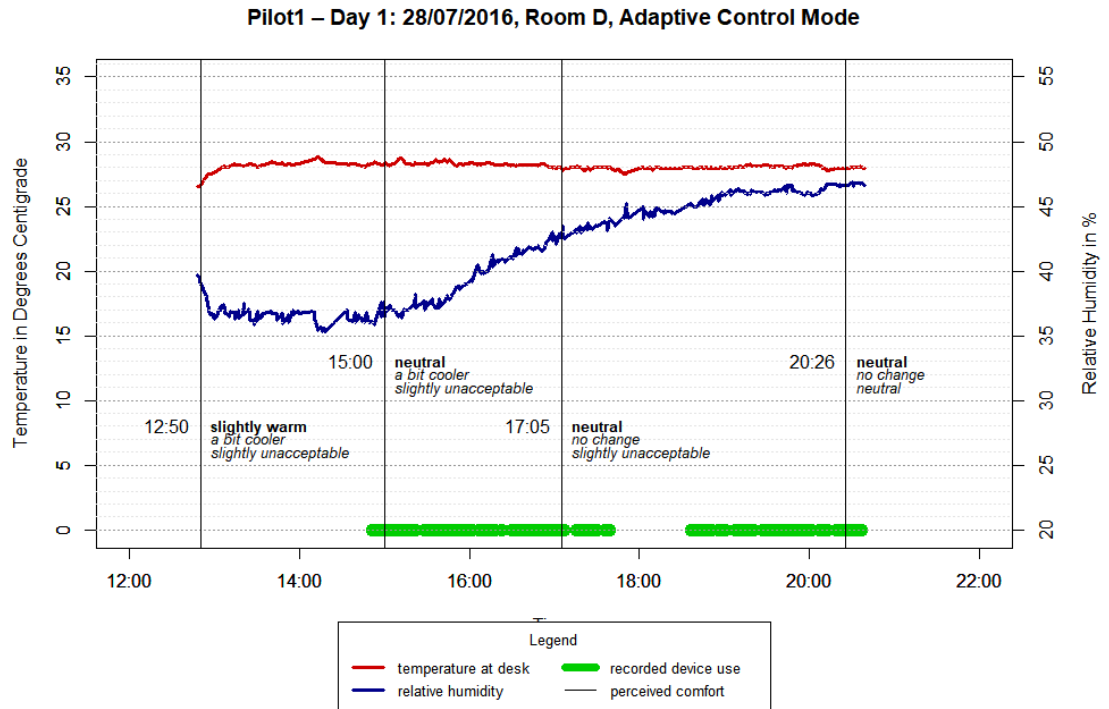
Outdoor Weather	Cloudy/grey
Clothing	Vest/sleeveless top, Jumper/Cardigan/Sweatshirt, Tights/legging, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
09:30	Walking (outdoors)	Lights on, Room heating/heater on	Cold	
13:30	Seated (passive)	Door open, Lights on, Room heating/heater on		Prototype (on) I felt hot
15:00	Seated (passive)	Door open, Lights on, Room heating/heater on	Cold	Prototype (on) I felt hot
17:00	Seated (passive)	Door open, Lights on, Room heating/heater on	Room temperature	

The experiment was terminated after day 4; no data recorded for last episode;

Pilot1

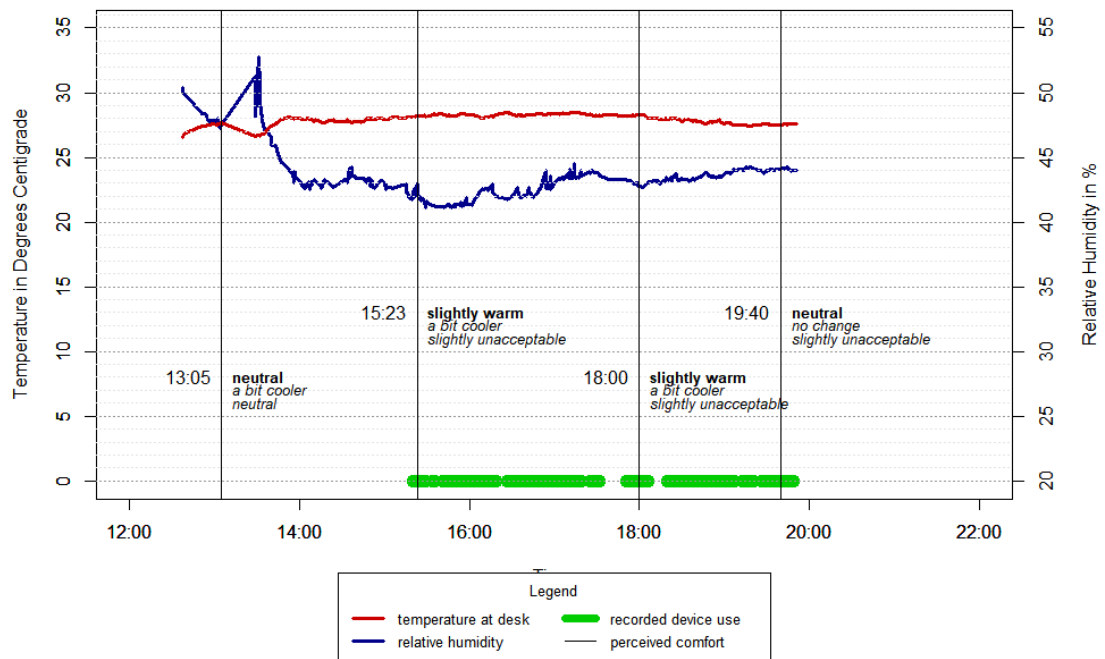
Pilot1 – Ambient Control Mode – Day 1



Outdoor Weather	Partly cloudy (12:50, 20:26), Cloudy/grey (15:00, 17:05)
Clothing	Dress, Short socks, Tights/legging, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
12:50	Walking (indoors), Walking (outdoors)	Air movement too high/low (too low) Window(s) open, Lights on	Room temperature	
15:00	Seated (active)	Air movement too high/low (too low) Window(s) open, Lights on	Cold	Prototype (on) I felt warm
17:05	Seated (passive)	Air movement too high/low (too low) Window(s) open, Lights on		Prototype (still on) (wanted to keep the same temperature)
20:26	Seated (active)	Window(s) open, Lights on		Prototype (still on) (wanted to keep the same temperature)

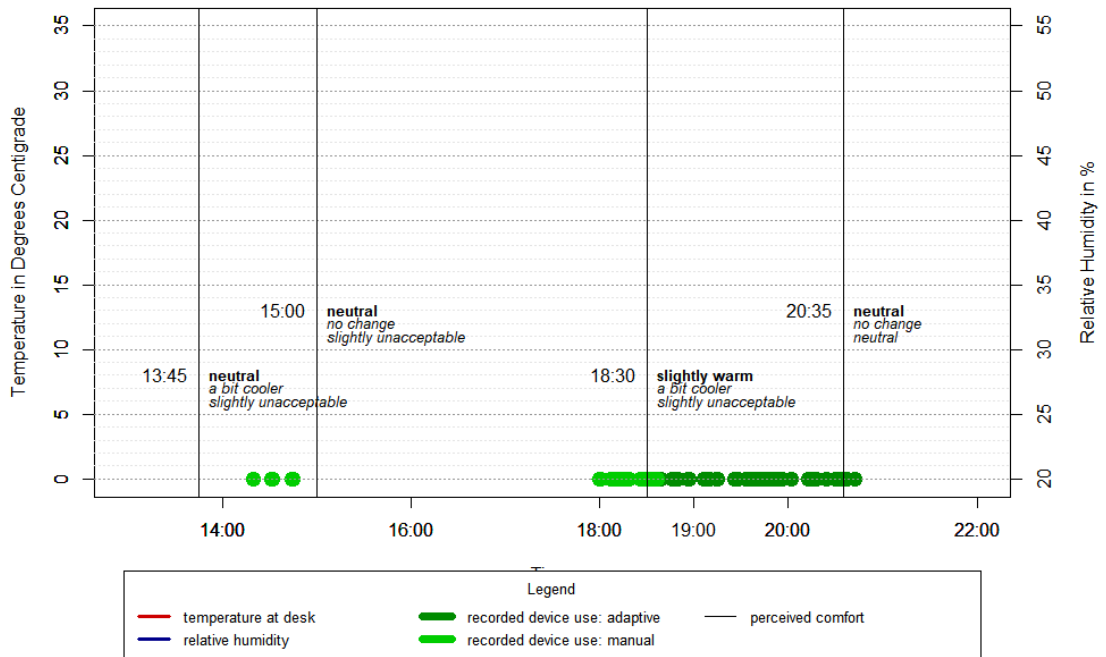
Pilot1 – Day 2: 29/07/2016, Room D, Manual Control Mode



Outdoor Weather	Cloudy/grey (13:05, 19:40), Partly cloudy (15:23, 18:00)
Clothing	Short sleeved shirt/top, Shorts/short skirt, Short socks, Tights/legging, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
13:05	Seated (active)	Air movement too high/low Window(s) open, Lights on		
15:23	Seated (active)	Air movement too high/low Window(s) open, Lights on		Prototype (on) I felt warm
18:00	Seated (active)	Air movement too high/low Window(s) open, Lights on	Room temperature	Prototype (still on) I felt warm
19:40	Seated (active)	Air movement too high/low Window(s) open, Lights on	Room temperature	Prototype (still on) I felt warm
Comments	(2) 15:56 (took the prototype off as it started overheating (even if not set at max/very high speed). Turned it to min end left it running to cool down. (3) 16:11 (I put the prototype back on as it had cooled down.)			

Pilot1 – Day 3: 01/08/2016, Room D, Selective Control Mode

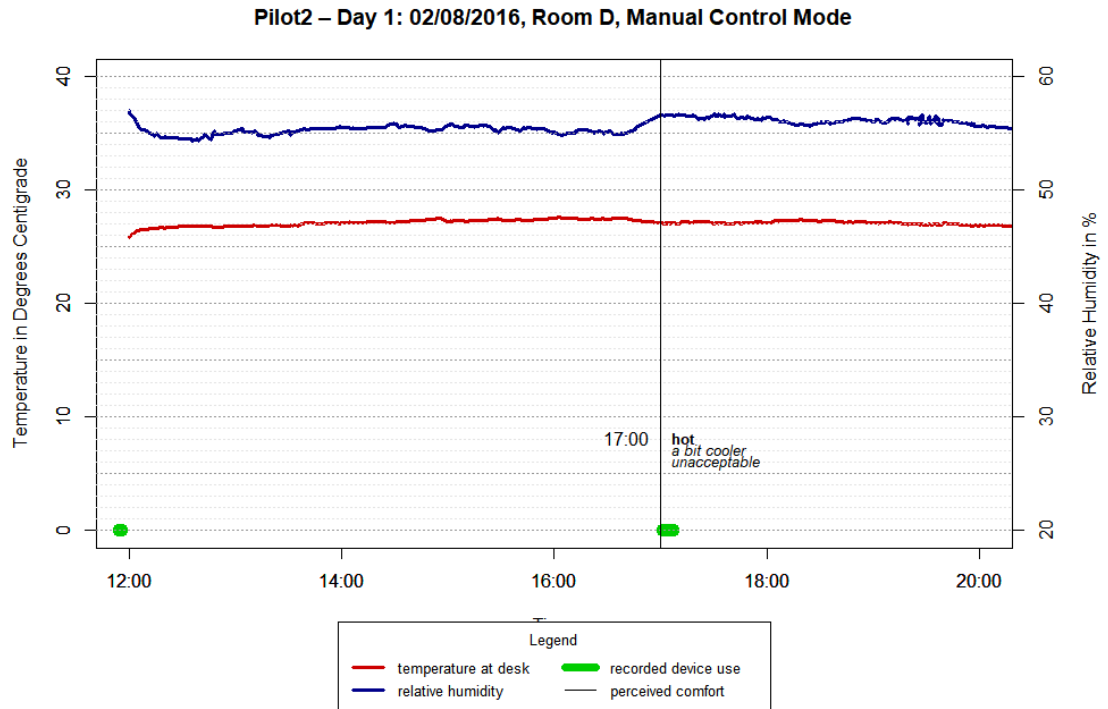


Outdoor Weather	Cloudy/grey, Drizzly (20:35)
Clothing	Short sleeved shirt/top, Shorts/short skirt, Short socks, Tights/legging, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
13:45	Seated (passive), Walking (outdoors)	Air movement too high/low (too low) Window(s) open, Lights on	Room temperature	Item of clothing (off, took my cardigan off when I got back into the office after walking outside to the supermarket) I felt warm
15:00	Seated (passive), Seated (active)	Air movement too high/low (too low) Window(s) open, Lights on		Prototype (on) I felt warm
18:30	Seated (passive), Seated (active)	Air movement too high/low (too low) Window(s) open, Lights on	Room temperature	Prototype (on) I felt warm
20:35	Seated (active)	Window(s) open, Lights on		Prototype (still on) I kept the prototype on because I wanted to keep the same temperature.

Pilot2

Pilot2 – Ambient Control Mode – Day 1

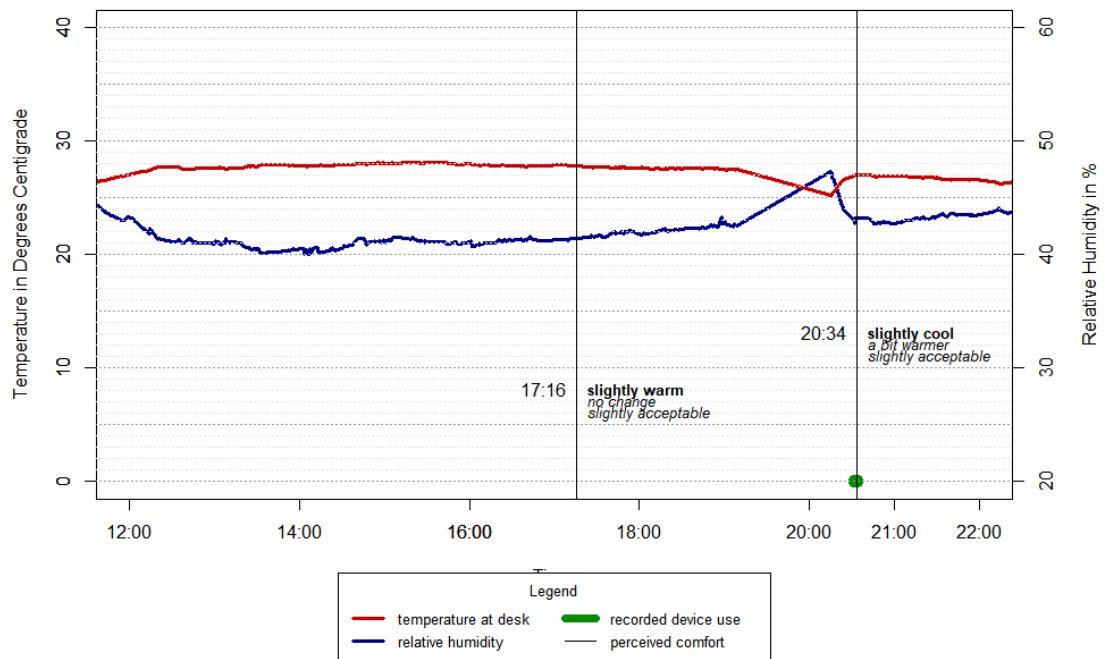


Outdoor Weather	Cloudy/grey
Clothing	Short sleeved shirt/top, Trousers/long skirt, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
17:00	Seated (active)	Air condition provides not enough cooling Window(s) open		Window(s) (open) I felt hot

Pilot2 – Ambient Control Mode – Day 2

Pilot2 – Day 2: 03/08/2016, Room D, Adaptive Control Mode

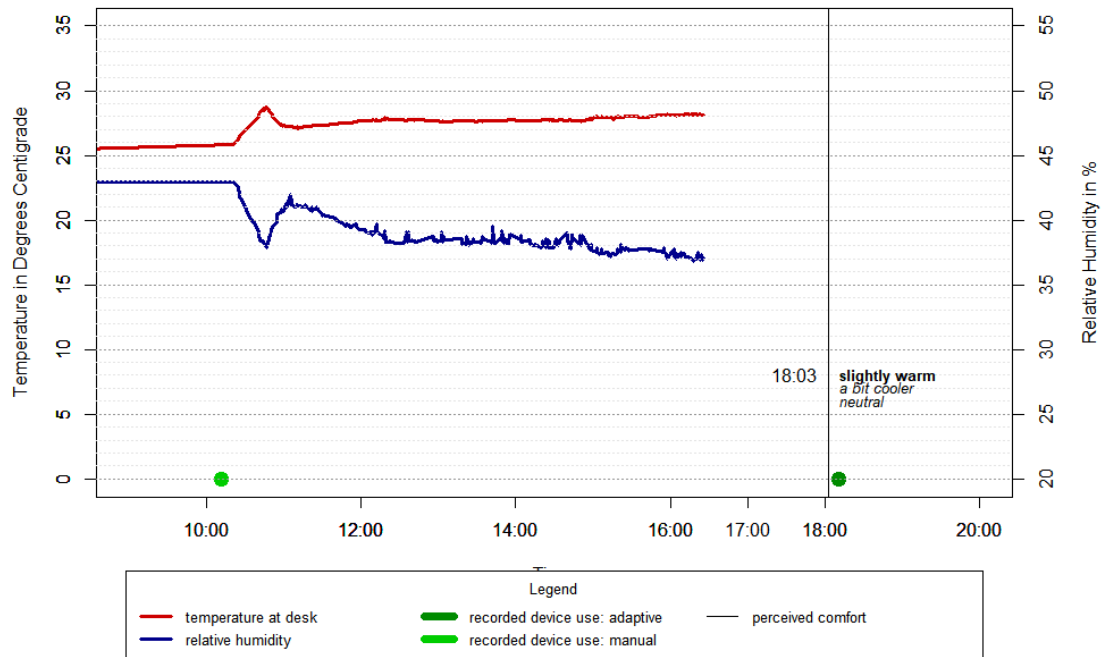


Outdoor Weather	Partly cloudy
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
17:16	Seated (passive)	Window(s) open, Lights on	Room temperature	Item of clothing (off), Window(s) (open) I felt warm
20:34	Seated (passive)	Window(s) open, Lights on		Item of clothing (on), Window(s) (close) I felt cool

Pilot2 – Ambient Control Mode – Day 3

Pilot2 – Day 3: 04/08/2016, Room D, Selective Control Mode



Outdoor Weather	Partly cloudy
Clothing	Short sleeved shirt/top, Trousers/long skirt, Short socks, Shoes

Data Points	Activity Level prior to survey	Environment	Food/Drink	Device Use / Behavioural Adaptation
18:03	Seated (passive)	Hot surrounding surfaces Window(s) open, Blinds/curtains down	Room temperature	Prototype (on), Window(s)(open) I felt warm

Appendix F

Ethics Approval

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F.1. Ethics Approval Pilot Survey

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Queen Mary Ethics of Research Committee
Hazel Covill
Research Ethics Administrator
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Email: h.covill@qmul.ac.uk

c/o Dr Karen Shoop
Eng E104
School of Electronic Engineering
Queen Mary University of London
Mile End Road London

23rd December 2014

To Whom It May Concern:

Re: QMREC1371b – PhD Student Comfort Survey

I can confirm that Ms Katja Knecht has completed a Research Ethics Questionnaire with regard to the above research.

The result of which was the conclusion that her proposed work does not present any ethical concerns; is extremely low risk; and thus does not require the scrutiny of the full Research Ethics Committee.

A protocol amendment (additional interviewing) was approved on the 23rd December 2014.

This amendment does not affect the assessment above.

Yours faithfully



Ms Hazel Covill
Research Ethics Committee Administrator

F.2. Ethics Approval Existing Devices Study

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Queen Mary Ethics of Research Committee
Hazel Covill
Research Ethics Administrator
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Email: h.covill@qmul.ac.uk

c/o Dr Nick Bryan-Kinns
CS 412
Department of Computer Science
Queen Mary University of London
Mile End
London

17th February 2015

To Whom It May Concern:

Re: QMERC1377 – Microatmospheres: Individual Comfort and Off-the-Shelf Personal Heating/Cooling Devices.

I can confirm that Ms Katja Knecht has completed a Research Ethics Questionnaire with regard to the above research.

The result of which was the conclusion that her proposed work does not present any ethical concerns: is extremely low risk; and thus does not require the scrutiny of the full Research Ethics Committee.

Yours faithfully



Ms Hazel Covill – QMERC Administrator

Queen Mary, University of London
Room W117
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Queen Mary Ethics of Research Committee
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c/o Dr Nick Bryan-Kinns
CS 412
Department of Computer Science
Queen Mary University of London
Mile End
London

15th June 2015

To Whom It May Concern:

Re: QMERC1377 – Microatmospheres: Individual Comfort and Off-the-Shelf Personal Heating/Cooling Devices.

I can confirm that Ms Katja Knecht has completed a Research Ethics Questionnaire with regard to the above research.

The result of which was the conclusion that her proposed work does not present any ethical concerns: is extremely low risk; and thus does not require the scrutiny of the full Research Ethics Committee.

A protocol amendment (additional and amended materials) was approved on the 19th March 2015.

A second amendment (revised materials and additional recruitment) was approved on the 15th June 2015.

These amendments do not affect the assessment above.

Yours faithfully



Ms Hazel Covill – QMERC Administrator

Patron: Her Majesty the Queen
Incorporated by Royal Charter as Queen Mary
and Westfield College, University of London

F.3. Ethics Approval Design Phase User Studies



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c/o Dr Nick Bryan-Kinns
CS412 – Department of Computer Science
Queen Mary University of London
Mile End
London

26th October 2015

To Whom It May Concern:

Re: QMREC1444 – Microatmospheres: Personal Heating/Cooling Devices

I can confirm that Ms Katja Knecht has completed a Research Ethics Questionnaire with regard to the above research.

The result of which was the conclusion that her proposed work does not present any ethical concerns; is extremely low risk; and thus does not require the scrutiny of the full Research Ethics Committee.

Yours faithfully

A handwritten signature in black ink, appearing to read "H. Covill", written over a light blue circular stamp.

Ms Hazel Covill – QMERC Administrator

Patron: Her Majesty the Queen
Incorporated by Royal Charter as Queen Mary
and Westfield College, University of London