Integrating Art into Bodily Interactions: Exploring Digital Art in HCI Design to Foster Somaesthetic Experiences

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Abstract

My interdisciplinary doctoral research of this thesis explored how interaction design – with a combination of digital art, body-centred practice and biophysical sensing technology – cultivates self-awareness and self-reflection to foster somaesthetic experiences in everyday walking. My research followed a *Research through Design* (RtD) approach to provide design artefacts as examples of research in the expanded territory of Somaesthetic Design, technology-enhanced body-centred practices and digital art applied in interaction design. Background research included a critical review of *Affective Computing*, the concept of somaesthetic experience, existing body-centred practices (e.g. mindfulness and deep listening), HCI designs for somaesthetic experiences, and interactive digital art applications (using biophysical data as input) to express bodily activities.

In methodological terms the research could be summarized as a process of 'making design theories' (Redström, 2017) that draws upon a *Research through Design* (RtD) approach. The whole research process could be described with a 'bucket' model in making design theories (Redström, 2017): identified initial design space as the initial 'bucket'; derived the first design artefact 'Ambient Walk' as a 'fact' to represent the initial design space and the cause of transitioning, re-accenting process from mindfulness to 'adding a sixth-sense' (i.e. to extend the initial 'bucket'); the making of second design artefact 'Hearing the Hidden' as a 'fact' to represent the re-accented research rationale in designing for somaesthetic experience by 'adding a sixth sense'. I followed a qualitative approach to evaluate individual user feedbacks on enhancing somaesthetic experiences, the aspects to be considered in designing for experiences, and how my design process contributed to refining design for experiences. At the end of this thesis, I discuss the findings from the two practical projects regarding the somaesthetic experiences that have been provoked during users' engagement with 'Ambient Walk' and 'Hearing the Hidden'; the inclusion of bodily interactions with surroundings in somaesthetic design; the use of 'provotypes' in experience-centred design practices; and the benefit of integrating digital art into technology for body-centred practices.

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Chapter 1. Introduction

Body-centred Practices, such as mindfulness practices, are effective practices that cultivate bodily experiences in everyday life. These practices augmented an immersive environment to strengthen practitioners' self-exploration and self-awareness. Visual arts and sound arts have been integrated into body-centred practices to better engage their practitioners (e.g. relaxation music and visual patterns have been used in many mindfulness practices) while less practices have explored using graphics/sound to respond to our bodily experiences. *Affective Computing*, initially proposed by Picard (1997), has provided technologies that enable machine understanding and communication with human emotional experiences. Technologies used in *Affective Computing*, such as facial expression recognition and biophysical sensing technologies, were able to recognise particular emotional cues within certain contexts (e.g. autism (el Kaliouby et al., 2006) and emotional eating (Carroll et al. 2013)). Moreover, biophysical sensing technologies were also applied in recognising human body activities alongside emotional experiences (e.g. *Affective Health* (Vaara et al., 2010) used biofeedback sensors to detect active level of the users alongside stress level). *Affective Computing* applications recognise emotional responses based on affective models aiming to cover most variations of emotions (e.g. the valance-arousal model by Russell (1980)). However, *Affective Computing* has limitations in understanding affective experiences that were not included in affective models. In the interdisciplinary field of Human-Computer Interaction (HCI), Experience-Centred Design is an approach that takes account of people's experiences with technology in the interaction design process (Wright & McCarthy 2010). Somaesthetic design, in particular, generates design artefacts that enhances the aesthetic perceptions of our bodily experiences (Höök et al., 2016). Researchers in pragmatic somaesthetic design have explored using biophysical sensing technologies and digital art making with data in their design artefacts to foster perceptual experiences of body, not limited to emotional experiences (e.g. *Soma Mat*, *Breathing Light and Sonic Cradle*). What could we find out if we do not focus on detecting emotional episodes, but use biophysical sensing technologies in a dynamic, body-centred interactive process that reflects and cultivates people's somaesthetic experience?

The interdisciplinary doctoral research of this thesis explored how interaction design – with a combination of digital art, body-centred practice and biophysical sensing technology – cultivates self-awareness and self-reflection to foster somaesthetic experiences in everyday

walking. My research followed a *Research through Design* (RtD) approach to provide design artefacts as examples of research in the expanded territory of Somaesthetic Design, technology-enhanced body-centred practices and digital art applied in interaction design. Background research included a critical review of *Affective Computing*, the concept of somaesthetic experience, existing body-centred practices (e.g. mindfulness and deep listening), HCI designs for somaesthetic experiences, and interactive digital art applications (using biophysical data as input) to express bodily activities.

The artefacts generated through this research were inspired by existing case studies from *Affective Computing*, somaesthetic design, HCI design for mindfulness and body movements, along with creative art practices for expressing bodily experiences. The practice of prototyping and conducting qualitative user studies aimed to provide practical case studies to unfold new knowledge relating to somaesthetic design with digital art in everyday activities (such as walking). The prototypes were openly evaluated by targeted users, including professional mindfulness practitioners, HCI researchers and the laypeople. As somaesthetic experiences are individually distinct and context-dependent, the evaluation adapted a qualitative approach to investigate individual experiences in context, with 'provotypes' (Boer & Donovan, 2012) to help identify possible somaesthetic experiences fostered by my prototypes.

In Section 1.1 I will provide the definitions of the key concepts and terms being discussed in this PhD research, including *Affective Experience, Somaesthetic Design, Body-centred practices, Digital Art* and *Research through Design*. In Section 1.2 I will identify the research questions that this research aims to answer. These questions provided impetus for this research, in terms of defining and exploring the design space with closely-related disciplines, and investigating existing theories and practice within it. In Section 1.3 I will outline the design space this research is exploring, based on the research questions. In Section 1.4 I will outline the structure of this thesis, which provides a logical flow for this account of the research and the insights generated from it.

1.1 **Definition of Key Concepts**

Affective Experience refers to human experiences of affection. Affection, according to Brian Massumi (1987, p.xvi), is "*the ability to affect and being affected"*. Affective experiences

encompass human sensations, emotions and perceptions from/of the body and the ongoing momentum of the surrounding environment (Columbetti 2013). In *Affective Computing*, affective experiences specifically refer to emotional experiences. To avoid ambiguity, Affective Experience in this thesis refers to human emotional experiences.

Somaesthetic Design refers to HCI design that cultivates somaesthetic experiences. It includes (but is not defined by) somaesthetic appreciation design, a strong concept proposed by Höök et al. (2016a), which emphasises design for inward-focused appreciation of bodily experiences. Somaesthetic design in this research not only delivers design for a stronger inward-focus of our own bodily experiences, but also for somaesthetic appreciation that occurred during our body's interaction with its surroundings.

Somaesthetic Experiences, according to Shusterman (1999), is the aesthetic experience of the *soma*—the perceptual quality of the body over time. Somaesthetic experience in this research will particularly refer to the affective bodily experience during an individual's interaction with the holistic environment that includes self-reflection and interactions with the surroundings.

Mindfulness Experience in this research refers to a state of mind that is highly aware of the 'here and now' without value judgement (MAPPG 2014). Mindfulness experiences include increased awareness of affectivity (including emotions, feelings, sensations, etc.) within the physical body and the ongoing momentum of the surrounding environment.

Body-centred Practices here refers to practices that aim to bring our focus to the body cultivating our attention and self-awareness. These practices foster practitioners' attention to their bodily sensations, perceptions, intuitions and thoughts (sometimes emotional responses) of our body. For example, mindfulness practices such as Mindfulness-Based Stress Reduction (MBSR) (Kabat-Zinn 2015) and walking meditation (Hanh 2006) that aim to increase our awareness of our bodily experiences.

The *Affective Loop* is a concept proposed by Höök et,al (2006) to describe a continuous affective experience, regarding the cause, the appraisal and the effect altogether. This is an alternative perspective on how we design and use technology to understand human affective

experiences regarding emotions as episodes in a single moment without understanding the context.

Digital Art: Digital art in this thesis refers to audiovisual artworks using digital technology. It is a form of digital media that delivers information derived from body movements, provoking perceptions and affective experiences of the mediated environment. *Digital Art methods* refer to the practical methods to create *Digital Arts*. The specific *Digital Art Methods* that have been adapted in this research are data sonification and visualisation (detailed explanation see Chapter 2).

Research through Design (RtD) is a practice-based research approach involving the making design artefacts in the pursuit of a research inquiry to generate 'new knowledge' (Frayling,1993). RtD may explore the possibilities of combining concepts and practices from various disciplines to form new design innovations. The design artefact of *RtD* is not only self-evident in the findings from the evaluation of the artefact, but the process of designing and making also contribute to such explorations. The practices of *RtD* have followed different traditions such as *Critical Design* (Dunne & Raby (2001) and Bardzell and Bardzell (2013)), *Research through Design* in *the lab, the field and the showroom* (Koskinen et al., 2011) and Redström' (2017) s 'making design theories', which will be discussed in detail in Chapter 3.

1.2 Research Questions

Grounded in a background review of the subject of interest, I conducted this doctoral research to explore the use of biophysical sensing technology in cultivating somaesthetic experiences, with digital art as a generative feedback to provoke individual reflections of somaesthetic experiences. The creative practice in this research set out to address the following questions:

1. *Can we cultivate somaesthetic experiences in walking by creating interactive apps that visualise and sonify our body activities vis-a-vis interactions with the surrounding environment?*

   And a linked question, 1(a): *What are the potential somaesthetic experiences one could engage by sonified walking and interaction with surrounding objects?*

Existing HCI designs for enhancing somaesthetics experiences explored making design artefacts to help users fully engage with their self-reflection in some exercises that foster unfamiliar body experiences (e.g. Feldenkrais for *Soma Mat* (Stahl et al., 2016)) while not many focused on creating novel experiences from exercises we are very familiar with or practicing every day. Many design artefacts of somaesthetic appreciation design explored creating spatial boundaries of user interactions to foster the inward-focus experience (e.g. *Sonic Cradle* (Vidyarthi et al., 2012) let users practice meditation in a chamber that reduces interactions not from the artefact itself.) With this question, my research aims to find out whether design artefacts with inspirations from somaesthetic design, body-centred practices such as mindfulness and deep listening and data visualisation/sonification in HCI and art practices to help in cultivating somaesthetic experiences in everyday walking. My research will not make hypotheses based on existing design practices, but rather it will generate artefacts inspired by both practices to explore such applications.

Aside from looking for answers to the first question, this research will also discuss the methodology that has been used, which is:

2. *How could we select research methods drawn upon Research through Design to generate design artefacts to enhance somaesthetic experiences in walking?*

    And a linked question, 2(a): *What may be some new/different practical methods selected for this research and why?*

HCI researchers, creative artists and makers have followed different traditions of RtD practices (e.g. Critical Design, the design practices in studio work, the constructive design in the lab, the field and the showroom and RtD in creating commercial products). Existing somaesthetic design practices have adapted different practical methods in the design process such as auto-ethnographic studies (e.g. in creating soma mat and breathing light, the designers practiced Feldenkrais themselves to form the design ideas), and co-design with target users (e.g. *Sonic Cradle* (Vidyarthi et al., 2012). How could we choose the relevant practical methods from existing practices, not limited to those applied in somaesthetic design studies, to deploy design artefacts to foster somaesthetic experience in walking, investigate users' experience with their body activities and discover the 'new knowledge' derived from the design studies? What might be some new practical methods could be applied in the context of creating interaction systems that enhances users' aesthetic perception of their body activities in walking?

3. *How could we position the design artefacts generated by this research in order to create new knowledge for somaesthetic design in walking? What could be a possible way to make 'new knowledge' through expanding the initial design space, making design artefacts and further extending the design space my findings are contributing to?*

In *RtD,* the 'new knowledge' may include new 'pack of practical methods/tools' from the design or evaluation process and/or new theory derived from a group of design practices. The design artefacts have been positioned as the interfaces that provoke certain user experiences (e.g. *soma mat*, *breathing light* and *drift table*) or invite discussions for future designs (e.g. *Sonic Cradle* (Vidyarthi et al., 2012) and Dunne & Raby's practices), yet there may be other roles the design artefacts were playing in a RtD project. When we study a certain user experience by creating design artefacts, we may discover novel user experiences that did not belong to the kind of experiences specified in the conceptual background of a research practice. What could be a possible way to develop future designs that consider these novel experiences and expand the design rationale with other areas that are still relevant to designing for somaesthetic experiences?

In addressing these questions, this research will involve designing various digital artefacts in the unfolding design space of somaesthetic design, body-centred practices and digital art-inspired methods. Two example design practices spanning the design space are proposed to provoke somaesthetic experiences in walking meditation and sixth-sense bodily experiences by listening to the surroundings: 'Ambient Walk' will explore somaesthetic experiences in visualisation and sonification of breathing and walking. Taking inspiration from walking meditation practice, the application will provide real-time audiovisual feedback to provoke awareness of body activities in exploring the harmony between breathing and walking. 'Hearing the Hidden' will investigate designs to enhance somaesthetic experiences via interactions with surrounding objects. The design artifact of 'Hearing the Hidden' will allow users reflect their body activities through listening to the echoes according to the detected distance from the nearest objects. By doing so, the aim is to investigate whether 'Hearing the Hidden' has strengthened users' awareness of their feelings, physical sensations and aesthetic perceptions of their body movements relating to the surrounding environment by listening to the echoes from their surroundings, and possibly extended their perceptual experiences by 'the

reflection of the self and the surrounding objects' (which could be regarded as ‘sixth-sense’ experiences).

1.3 The Design Space

In forming the rationale and conceptual foundations of this research, I begin with a process of identifying the design space with existing research areas that inspire my design practice. The process of forming the design space started with critical reviews of Affective Computing, an area that provided state-of-art technologies to understand human emotions, regarding the reductiveness of the affective models (e.g. Russell (1980)) been used. My research interest was then moved onto exploring broader bodily experiences that affect and being affected by our activities and the environment around us. Somaesthetics is a research discipline proposed by Shusterman (1999) that investigates improving people’s perceptual experiences of their body. HCI design studies about somaesthetic experiences have provided some examples of making interactive objects, interfaces and installations to foster users’ awareness and self-reflection of their body activities. In designing for somaesthetic experiences, existing studies have integrated body-centred practices (such as Feldenkrais (Feldenkrais, 1987) and mindfulness meditation) to foster awareness of users’ body activities. Example body-centred practices adapted in somaesthetic design focus on increasing users’ attention to their body by either encountering unfamiliar experiences (e.g. in Feldenkrais (Feldenkrais, 1987), practitioner can hold their breath to be highly aware of their body reaction during breathing), immersive experiences (e.g. *Sonic Cradle* (Vidyarthi et al., 2012) enhanced users’ mindfulness experience by creating immersive environment with sonification of breathing) and active listening/seeing (e.g. *deep listening* (Oliveros, 2005)). Digital Art methods, especially data visualisation and sonification, have been used in many art installations (e.g. *Cardiomorphologies* (Khut, 2016) and *E.E.G. Kiss* (Lancel & Maat, 2014)) and interaction design projects (e.g. *Affective Health* (Vaara et al., 2010), *Sonic Cradle* (Vidyarthi et al., 2012) and *GangKlang* (Hajinejad et al., 2016)) to creatively respond and reflect human body activities (e.g. heart rates, breathing, etc.) A detailed discussion of the expansion of the design space will be included in Chapter 2.

To explore designs for somaesthetic experiences with digital art methods, my research investigated existing practices in the areas of HCI design for somaesthetic experiences, body-centred practices (such as mindfulness) to enhance attention and awareness of bodily

experiences, and digital art methods that have been integrated in artworks and HCI design artefacts to reflect personal bodily experiences. The design space of this research departed from Affective Computing, taking HCI design for somaesthetic experiences and body-centred practices as its dimensions and digital art methods (e.g. data visualisation and sonification) as techniques to create novel interactions for my design artefacts. Following the RtD approach, this research may explore design practices in the extended territory of the initial design space, or unfold other relevant areas of inspiration based on the findings from literature review and the actual design practices--'Ambient Walk' and 'Hearing the Hidden'. Note that the design space mentioned in this section is populated with the sources that inspired my design practices, but not necessarily the areas my research is contributing to. For example, my design practices would be inspired by the technologies used in *Affective Computing*, yet my practices may not fall into the scope of Affective Computing. The extended territory does not exclude the research areas that inspired my design practices. My design practices described herein took inspiration from the concepts, case studies and methods out of HCI design for somaesthetics, body-centred practices and data visualisation/sonification, while still contributing to or located in some of these areas.

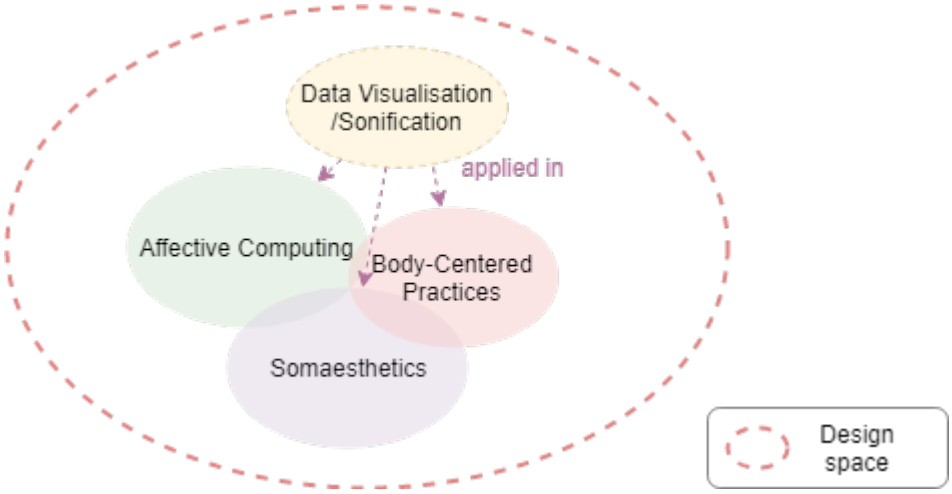

Fig. 1 Diagram of the initial design space, which unfolds throughout this research

HCI design for Somaesthetic Experiences refers to HCI discourse on designing with aesthetic perceptions of bodily experiences such as body movements in walking, body sensations and perceptions in practices such as Feldenkrais (Stahl et al., 2016) and sitting meditation (Vidyarthi et al., 2012). As my research focuses on exploring technology innovation in fostering people's somaesthetic experience, this is the core area to be explored, and the main guideline for the creative practices in this research. The exploration in this area will investigate the design contexts, purposes, technologies/interaction mechanisms to stimulate

somaesthetic experiences and evaluation methods of existing HCI design practices to identify the design rationale and methods to be used in my own design practices.

Body-centred Practice refers to the research area of widely adapted mind-body practices (such as mindfulness and *deep listening* (Oliveros, 2005) that have the potential to enhance personal bodily experience on a day-to-day basis. This includes the concepts of these practices, how they help in cultivating bodily experiences and existing technology innovation in such practices. This area inspired my research by providing existing practices that could help me generate design sources for my creative practices.

Data Visualisation/Sonification are practical methods to create visual/audio representations of collected data in order to provide a responsive and entertaining environment for audiences to engage with what they aim to deliver. These methods are widely used in digital art practices to bring audiences a novel, ludic and enjoyable experiences. Data visualisation usually involves creating graphical representations of the data collected. For example, Khut's *Cardiomorphologies* (2016) used animated circles and squares with different sizes and colours to represent participants' heart rates. Creative artists have explored using objects' physical movements to visualise and sonify body data, which not only expressed artists' biophysical feedbacks (e.g. the E.E.G Kiss (Lancel & Maat 2016)) but also provided visceral mimics of the body activities to foster the users' self-reflection (e.g. Mind Pool (Long & Vines 2013) and Vicious Circular Breathing (Lozano-Hemmer 2013). Reviews of such practices showed that digital art/media methods have the potential to intervene in, and possibly cultivate reflective bodily experiences.

1.4 Structure of the Thesis

In Chapter 2, I will identify the theoretical grounds of HCI design for somaesthetic experiences, body-centred practices and digital art methods in making interactive installations with biophysical sensing technology. This includes an overview of the three areas, where the connections lie and how they are related to my design-led projects. Drawn upon the literature review I will also specify the design rationale of my research as in the extended area of the initial design space. In Section 2.1 I will provide a critical review of *Affective Computing* regarding its focus of understanding emotional experiences based on *Affective Models*. Based

on the review of *Affective Computing*, I will discuss how I positioned my design practices in the expanded area of *Affective Computing* to cultivate our bodily experiences besides emotional experiences identified in *Affective Models*. In Section 2.2 I will review the area of HCI design for somaesthetic experiences including the concept of soma and somaesthetics, Shusterman's interest in pragmatic somaesthetics research and HCI design for somaesthetic appreciation. In Section 2.3 I will discuss two examples of body-centred practices, mindfulness and deep listening, that are widely adapted by the public and artistic practices. Sections 2.4 will review existing creative art and HCI practices that fostered users' somaesthetic and other bodily experiences regarding their visualisation/sonification methods, the particular bodily experiences users engaged, the evaluation from various perspectives and how each practice inspired my design practices. In Section 2.5 I will introduce commonly used digital art methods, data visualisation and data sonification, to express artists' understandings of somatic experiences and/or to reflect audiences' somatic activities. At the end of this chapter (Section 2.6) I will summarise the literature review and the unfolding process of my design space, and introduce how this process inspired my research methodology and design practices.

In Chapter 3, I will describe the research methodology, approach and practical methods for design, development and evaluation. It includes an introduction to Research through Design (RtD), the general approach taken in this research, with a comparison to similar approaches (*i.e. Research into Design*, *Research for Design* and *Research through Art*) to justify the relevance of this approach. In Section 3.2, I will review various traditions drawn upon the Research through Design approach and discuss which tradition my research will follow, including *Research through Design* in design studio work (e.g. *The Curious Home* (edited by Beaver et al., 2007)), *Critical Design, RtD* focusing on creative practice element in *lab, field and showroom* (Koskinen et al., 2011) and *RtD* for making commercial products to contextualise my RtD approach in relation to others. Based on the discussion in Section 3.2, I will further discuss the practical methods for delivering artefacts that provoke personal experiences, i.e. making 'provotypes'(Boer & Donovan, 2012) in Section 3.3. For evaluation of somaesthetic experiences, I will discuss about the qualitative methods that I used to openly evaluate user data based on individual contexts in Section 3.4. In Section 3.5 I will introduce some practical methods used to document research findings throughout the design practices and user evaluations of the design artefacts, including *Annotated Portfolio* (Bowers, 2012)

and *Strong Concept* (Höök & Löwgren, 2012). In Section 3.6 I will state the ethical concerns and ethical approval obtained for conducting this research.

In Chapter 4, I will introduce the first practical project for this research, 'Ambient Walk'. This chapter will include the background theories and practices that particularly inspired this design practice (section 4.1); the experiments to collect design sources and inspire the initial design and prototyping, including my own walking meditation practices with various sensors, interaction mechanisms and visualisation/sonification mappings with different data (section 4.2); the autobiographical evaluation of 'Ambient Walk' prototype in my own walking meditation over several days (section 4.3); the initial user engagement at a conference exhibition, the Interactions Gallery at British HCI (2015), describing user feedback on the kind of bodily experiences engaged (Section 4.4); the design iteration in collaboration with sound artists (Section 4.5); and a linked, empirical study of 'Ambient Walk' with mindfulness practitioners and people who had previous experiences with mindfulness practices (Section 4.6). At the end of this chapter, I will discuss the findings from user feedback from both the Interactions Gallery engagement and from the empirical user study, on users' awareness and aesthetic perceptions of their body activities in walking, the novel bodily experiences users engaged other than mindfulness experiences, the methods been applied in 'Ambient Walk', and the perspective of studying somaesthetic experiences vis a vis bodily interactions with the surrounding environment. I will describe the novel bodily experiences that users reported with 'Ambient Walk' and the shift of perspective in studying somaesthetic experiences, and how the findings from the 'Ambient Walk' case study informed a further RtD study for my research, 'Hearing the Hidden'.

Chapter 5 will describe this follow-on study, 'Hearing the Hidden'. My creative, RtD practice in this study aimed to extend my research exploration from enhancing inward-focused experience to embracing users' awareness of bodily experiences reflected in their interactions with their surroundings. The project began by exploring the concepts of human echolocation and deep listening (sections 5.1 and 5.2). These concepts were then applied in the sound and interaction design of 'Hearing the Hidden'. Section 5.3 will introduce the design and prototyping of 'Hearing the Hidden', including my experiments with different devices, wearable pieces, interaction flows and environment settings (e.g. the layout of the space, indoor or outdoor, lightings, etc.). In Section 5.4 I will discuss the users' feedback on their experiences with 'Hearing the Hidden' during the user experiments, looking at their bodily

experiences, their intentions and thoughts during their explorations, the variation of somaesthetic experiences in dark and bright spaces, and how ‘Hearing the Hidden’ enabled ‘sixth-sense experiences’ as a kind of somaesthetic experience.

In Chapter 6 I will discuss the findings of ‘Ambient Walk’ and ‘Hearing the Hidden’, exploring users’ somaesthetic experiences within their body and bodily interactions with the surroundings. The discussion will also cover what should be considered in experience-centred design and the making of provotypes. This chapter will also include a cross-disciplinary discussion about how digital art helped to foster bodily experiences. In Section 6.1 I will reflect on user awareness, thoughts and intentions during the use of ‘Ambient Walk’ and ‘Hearing the Hidden’. In Section 6.2 I will discuss how the practical methods selected for this research were effective in delivering the findings of my research in the context of designing for somaesthetic experiences with digital arts. Specifically, Section 6.2 will focus on discussing how making ‘provotypes’ provoked somaesthetic experiences that ‘Ambient Walk’ and ‘Hearing the Hidden’ aimed to explore, enabling a positioning of the design artefacts as contributions to the research areas being explored and how the novel experiences out of the targeted kind of user experience informed further design explorations (i.e. some somaesthetic experiences user engaged with ‘Ambient Walk’ were not mindfulness experiences, while informed the design of ‘Hearing the Hidden’). In Section 6.3 I will discuss opportunities for conducting further design research by expanding the design space and articulating how the role of the design artefacts and the findings contribute to other research areas. Chapter 7 will conclude this PhD research with a brief reflection on the research questions, the methodology and practical methods drawn upon *Research through Design* and the findings from the two creative practices to annotate the contribution of this research to HCI design inquiry.

Chapter 2: 'The Living Body': Exploring Somaesthetics Experience in the Expanded Design Space Beyond Affective Computing

In this chapter I will provide an in-depth overview of the theoretical background that guided and inspired my design practices, and which formed the dimensions of the design space. The theoretical background of this research includes three parts: I) The departure point of my design space and its expansion: including a review of *Affective Computing* as initial technology inspiration with reductiveness of existing models of *affect* in *Affective Computing*; and the potentials of designing in the expanded territory based on a broader understanding of *affect* and how this exploration entered the area of somaesthetics. II) The case studies that inspired my design practice: existing body-centred practices that aim to foster our perceptive experience of the body, such as mindfulness and deep listening. And III) The methods and techniques: existing HCI designs, art installations and creative techniques to represent body data and to create responsive interactions that foster our bodily experiences in walking. In Section 2.1 I will critically review *Affective Computing* regarding its modelling of *affect*. This leads to a discussion of how my design space expanded from *Affective Computing* to the broader territory of designing for bodily experiences based on existing discussions of *affect*. Following that, in Section 2.2 I will review Shusterman's publication of research on *Somaesthetic* experiences. This section will cover how Shusterman defines *soma* and *Somaesthetic* experiences, his interest in somaesthetics research and related pragmatic studies to explore somaesthetic experiences. Section 2.3 introduces existing body-centred practices, *Mindfulness* and *Deep Listening*, that have been adapted in clinical practice, HCI technology innovation and digital art practice. In Sections 2.4 I will review existing creative art and HCI practices aiming to foster somaesthetic and other bodily experiences regarding their visualisation/sonification methods, the kind of bodily experiences users engaged and the evaluation from various perspectives. Section 2.5 will review data visualisation and data sonification, two approaches been applied in various artistic, scientific and engineering areas (such as digital art creation and scientific data representation), that have been applied to represent bodily experiences and to create an augmented layer for self-reflection and communication of affective experiences.

2.1 From Critical Review of Affective Computing to the Expansion of Design Space for Bodily Experiences

My research was motivated by my interest to design for interesting interactions with awareness of affective experiences in everyday activities such as walking. *Affective Computing* is the research area focusing on making machines understand and communicate with human emotions. This section will review what affective experience have been explored in *Affective Computing*, the technology development of *Affective Computing* algorithms regarding various modalities of emotions, the *Affective Loop,* along with major limitations of *Affective Computing* and less explored areas of technology for *affective experiences*. Based on the review, this section will also discuss about expanding my design territory from the rationale of Affective Computing to a broader rationale of making technology for *affective experiences* in the living body, beyond the notion of emotional experiences specified by affective models.

In 1997, Rosalind Picard proposed *Affective Computing* as an area of study in Artificial Intelligence and cognitive computing as *"computing that relates to, arises from, or influences emotions"* (Picard, 1997, p1). Picard (2003, p55) made an analogy between human emotion and the weather, stated that *"The term emotion refers to relations among external incentives, thoughts, and changes in internal feelings, as weather is a superordinate term for the changing relations among wind velocity, humidity, temperature, barometric pressure, and form of precipitation."* Like scientists can measure qualities like velocity, humidity, temperature and barometric pressure to determine weather events, Affective Computing applications determine emotional events (such as excitement and anger) by developing algorithms to analyse measurable qualities such as facial expressions, heart rates, skin conductance etc. (Picard, 2003). The basic requirement of Affective Computing algorithm at that time, according to Picard (2003), was to determine emotional events (which she compared them to extreme weather events such as blizzards) so that people know how to react (like people would know how to prepare for blizzards). The emotional events, in Picard's publication of major challenges of *Affective Computing* (2003), were referred to Ekman (1993)'s specification of six basic emotions: sadness, anger, fear, disgust, joy and surprise. Later Affective Computing studies explored further than recognition of emotional events to consider continuous changes of emotional responses and variations of emotional events, which Russell (1980) referred as emotional arousal and valence in their proposed valence-

arousal model prior to Ekman (1993)'s six basic emotions. Technology innovations of *Affective Computing*, whether developed to understand emotional experiences: or to apply the ability of understanding emotional experiences into other research areas, were mainly based on and/or aiming to expand existing affective models.

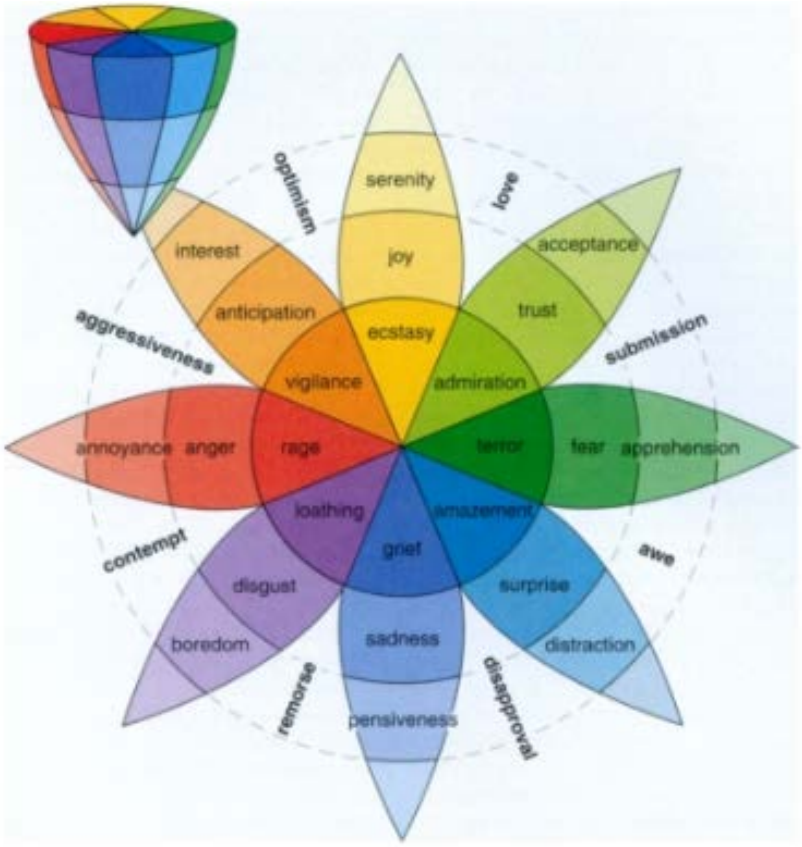

Fig2.1.1 Russell & Plutchik's emotion wheel

Early practices of *Affective Computing* have explored technology innovations and methods to recognise emotional events (such as joy and anger) via different measurable modalities, including facial expressions, eye movements, biophysical feedbacks etc. Some measurable modalities were measured via graphic-based technology. For example, for facial expression recognition, El Kaliouby et al. (2006) introduced the 'Mind-reading machine' to understand emotional expressions from people with autism by mapping their facial expressions to pre-identified emotion model. After founded Affectiva.Inc, El Kaliouby collaborated with McDuff et al. to develop Affectiva's commercial products based on facial expression recognition with the Affectiva-MIT Facial Expression Dataset (AM-FED) (McDuff et al., 2013) in various applications such as analysis of audience engagement for advertisements (McDuff et al., 2015). Graphic-based technology has also been applied to recognize emotional behaviours, such as gestures and kinetic movement (Psarrou et al. 2002; Fagerberg & Höök, 2003; Castellano et al. 2007). *Affective Computing* has also developed technology to detect emotions from vocal behaviour (Faulkner & Davison, 2004). In detecting continuous

changes of emotions, Affective Computing also investigated biophysical signal detection for emotional arousal (Lindström et al. 2006; Yamada & Watanabe, 2004-2006; Jimenez et al., 2010). Besides developing technology to understand emotions, *Affective Computing* studies have also explored designing for *Affective Loop* (Höök, 2008). In the *Affective Loop*, affective state is not an independent instance at a single moment, but is tied to its social context or another affective state in the previous moment. Such affective state may lead to another state based on the context and thus forms an emotional continuum. Design artefacts to reinforce *Affective Loop* not only recognise and report emotional states, but also respond, sometimes intervene, towards people's reactions driven by their emotional experiences (Höök, 2008). For example, Sundström et al. (2007)'s *eMoto* allows users to express their emotions in their messages sent to friends. Users who receive friends' *eMoto* messages would also interpret the emotional meaning of the messages and reply with their own expression of emotional experiences by selecting background colour and patterns of *eMoto* message. Similarly, Vaara et al. (2010) design and developed *Affective Health* app which visualises users' body movement, heart rates and skin conductivity in a form of continuous spiral with colour spectrum, intensity and shapes. To use the *Affective Health* app, user wear a biophysical sensor paired with the app on their wrist to record real-time biofeedbacks. The visualisation of users' biophysical data may drive users into an *Affective Loop* when users encounter emotional reactions during their self-reflection process.

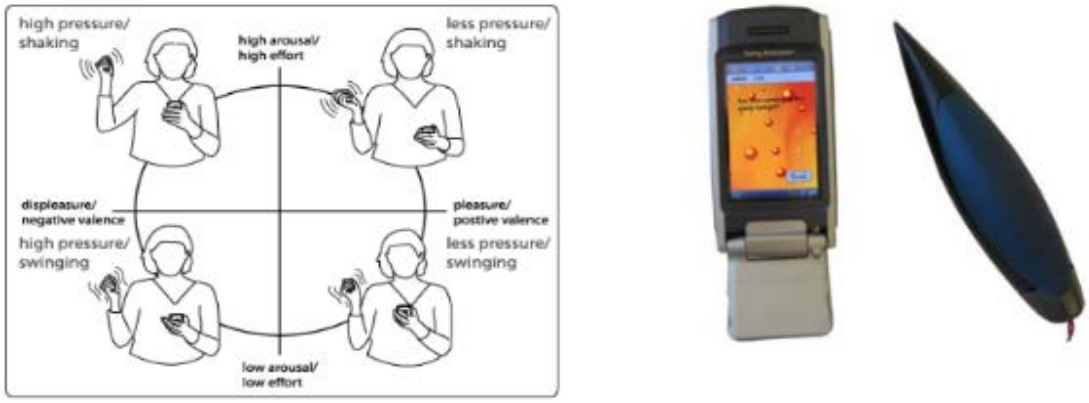

Fig 2.1.2. Mapping User Interactions with eMoto to the Valence-Arousal Model (Left); The User Interface and Sensor for eMoto (Right)

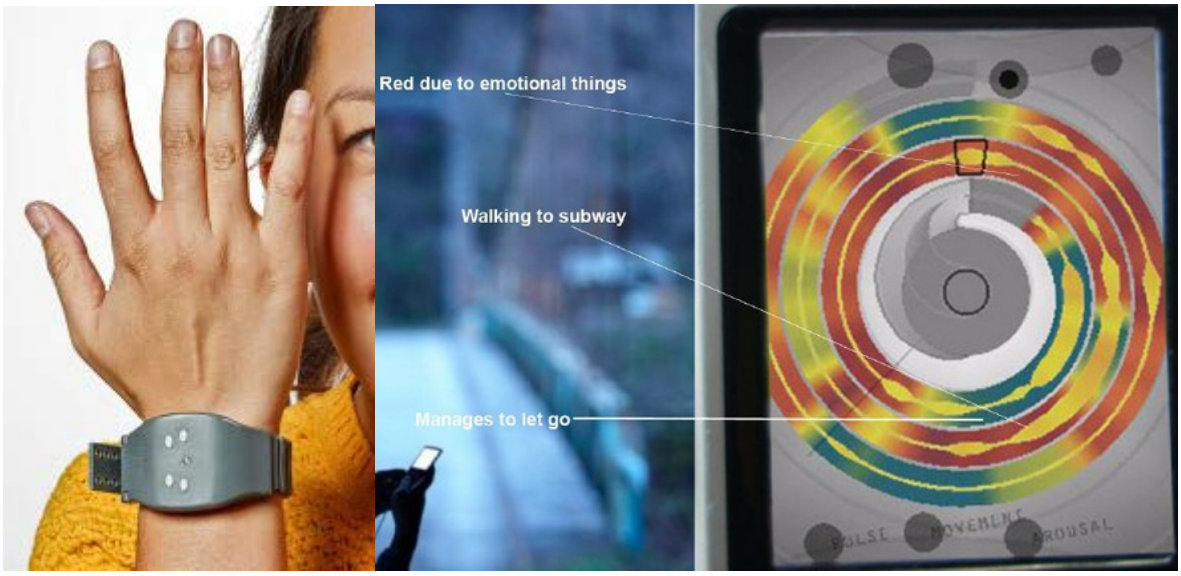

Fig 2.1.3 The wearable sensor and visualisation design of *Affective Health (Vaara et al., 2010)*

Affective Computing technologies have been applied in many areas such as social science, education, health and psychology to understand or mediate emotional expressions. McDuff et al. (2015) developed Affdex software to detect audience engagement based on users' facial expressions. El Kaliouby et al. (2006) applied facial expression recognition to help people with autism enhance social skills. Lindström et al. (2006) applied biophysical sensing of emotional experiences in designing *Affective Diary* for self-reflection of emotional experiences and everyday wellbeing. Carroll et al. (2013) designed an intervention method to reduce negative feelings with wearable stress detection sensors, aside from their first study of emotion recording. By making users aware of their emotional eating and deep breathing, it has effectively interfered with their eating behaviour to help establish a healthier lifestyle.

Recently, creative artists and practitioners explored applying affective technology and digital art to reflect or creatively express artist's' interpretation of human emotional experiences. Simbelis et al.'s *Metaphone* (2013) integrated continuous machine drawing to express, reflect and provoke participants' emotional activities. The *Metaphone* (Simbelis et al., 2013) explored the potential of fostering 'Affective Loop' experience via observing the dripping of the ink from the drawing machine and listening to the soundscape combining representation of biofeedback data and machine movements. In making the *Metaphone*, Simbelis et al. (2013) made a bio-ball with integrated sensors to track users' body movements, heart rates and skin conductance. These biophysical data were then mapped with machine drawing movements, ink colours, stroke thickness and so on to paint looped curves on a large paper on

the floor and rhythmic soundscape together with the machine movement sound. While *Affective Health* (Vaara et al., 2010) created an abstract graphical representation of users' biophysical data and body movements, *Metaphone* added a modality of machine movements to bring an active perception of emotional experiences and body activities.

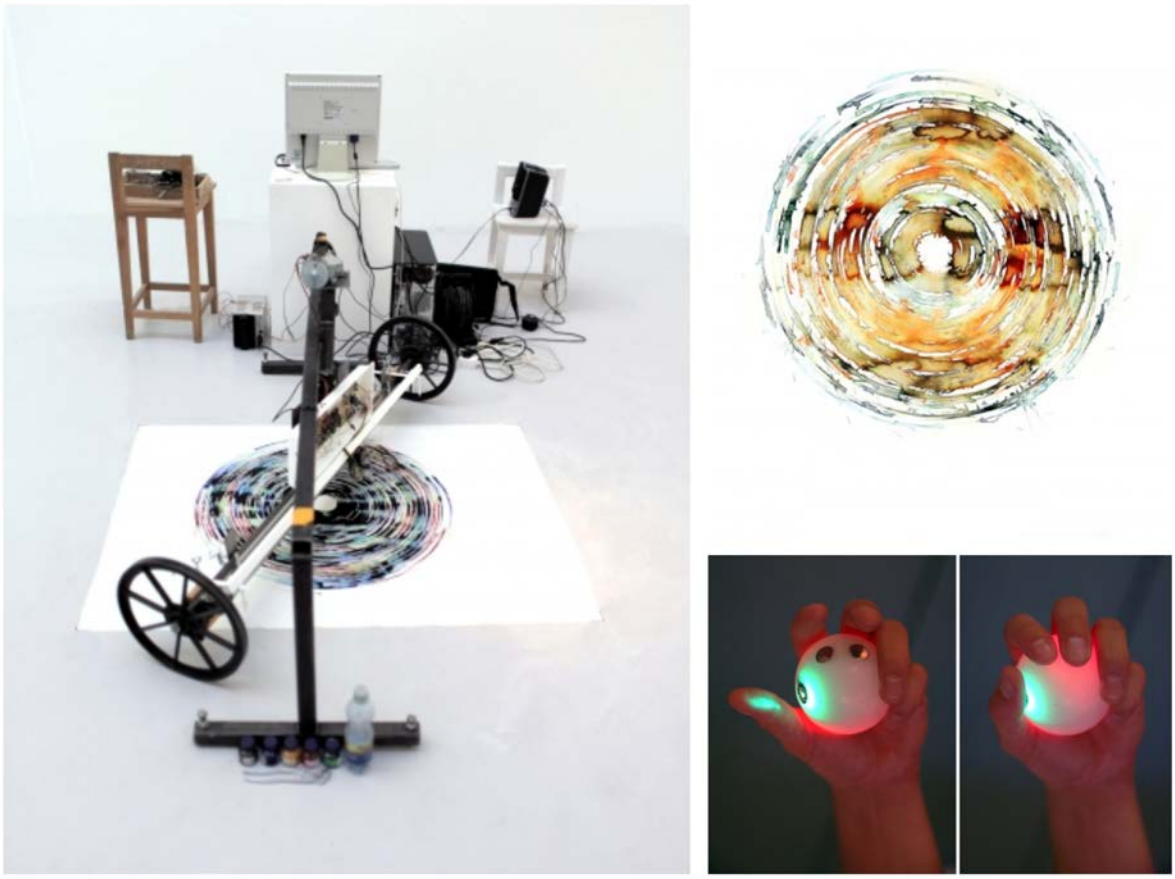

Fig 2.1.3 The drawing machine, a sample drawing on aquarelle paper and the bio-ball to collect biofeedbacks for Simbelis et al. (2013)'s *Metaphone*
(photos from http://www.simbelis.com/project/metaphone/).

In art performances, Lisa Park (2016) combined emotion recognition with Brainwaves (EEG) and physical visualisation with motions of water in her performance *Eunoia II* in 2016. During the performance of *Eunoia II*, the Brainwave signals were mapped with various emotions such as engagement/boredom, frustration, meditation and excitement. These emotions were then mirrored into water motions from different plates located at different locations (Park, 2016). These water motions at various locations represent Park's expression of her emotional experiences. Bowers and Green (2018) created Emotion Recognizer-Generators among their many makings with machine listening, which detects 'emotions' from input audio streams and generate synthesized sound effects pre-mapped with 'emotions'. The 'emotions' to be detected by Emotion Recognizer-Generators are based on the mapping

among listeners' emotional experiences and the six features of music: timbre, tempo, mode, register, articulation and dynamics (Bowers & Green, 2018).

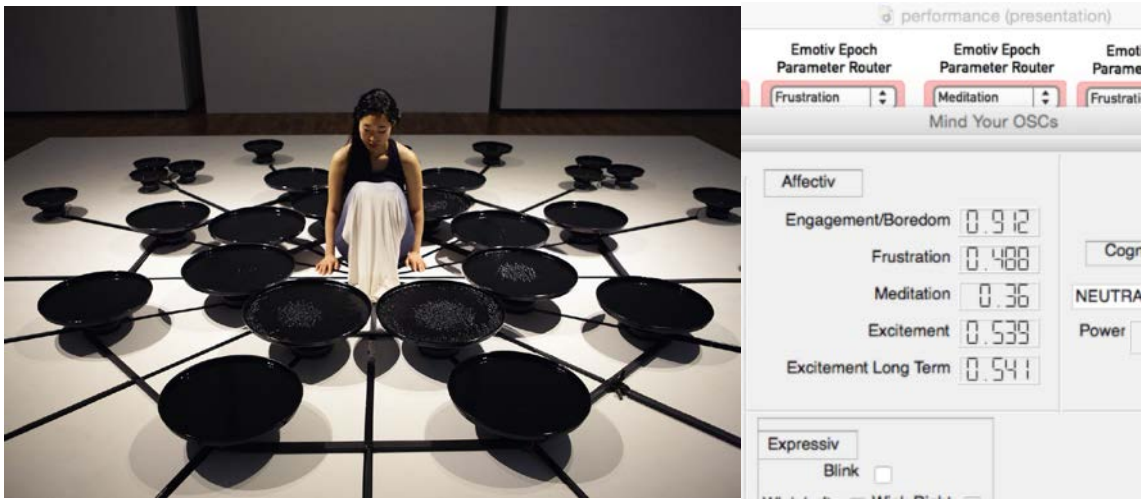

Fig 2.1.4 During the performance of *Eunoia II* (Park, 2016) (Left); The Interface illustrate Affectiv and Expressive data of *Eunoia II* (Right). Pictures from http://www.thelisapark.com/eunoia-ii/.

In *Affective Computing*, technology recognises emotional states based on affective models. Some most commonly-used affective models include Ekman's (1993) six basic emotions and Russell's affective model (1980). The affective experiences recognized by the affective models were referred to Russell's writing of *Core Affect* (2003). *Core Affect* identified different levels of affects from a phenomenology perspective. It defines the basic affective dimensions as valence and arousal, with a number of basic emotions with specific bodily features (e.g. body temperature, heart rate and facial expression) within that. When we review the models been applied in *Affective Computing*, they are usually a simplified categorization of affects according to certain patterns (e.g. facial expression, body movement trajectory etc.) at one moment, which sometimes neglected the context of the affective state. When we review the philosophical dissemination of *Affect*, Massumi (1987, p.xvi) described affection as *"an ability to affect and be affected. It is a pre-personal intensity corresponding to the passage from one experiential state of the body to another and implying an augmentation or diminution in that body's capacity to act."* From Massumi's definition, we could see that: affective experiences occurred not only in the fragment experiential moments/states, but also in the transitions from one moment to another; affective experiences generally exist when our body is 'affect and being affected', not limited to emotional experiences. As Kriegel (2011) argued that embodied feelings or 'the feeling of body' are the outcome of affection, research in affect-based technologies could be extended from interpreting 'the emotional feeling of the body' (or 'the expressions of emotional affection')

to understanding a broader notion of 'feeling' of the body, including physical feeling, aesthetical perception and so on. In *Affective Computing*, researchers studied changes of bodily experiences (e.g. galvanic skin response, muscle tension etc.) relating to emotional responses, yet emotional responses were only one of the many possibilities that caused such changes. People had harder breath or higher pulse rate at a moment could be either he/she was stressful, anxious, or just completed exercises. These biophysical responses may not be emotional responses, yet they are bodily experiences resulting from 'affect and being affected' during interactions with the world. These experiences and their contexts are novel, interesting experiences to be investigated when we are aiming to understand and cultivate our everyday experiences by design.

For this research, I position my design exploration in the extended territory of *Affective Computing* with the broader area of bodily experiences, not limited to emotional experiences. The design practices will explore digital applications that enrich our bodily experiences in everyday activities, involving many makings that combine sensor technologies used in various body-centred design practices (including *Affective Computing*) and digital art practices for creative expressions of bodily experiences. This research will use walking as an example of everyday activities to develop research case studies as walking is *"a ubiquitous, mundane, everyday activity that can involve a number of different experiences: from the incidental to the meditative and the arduous; from choreographed and socialized movement to accidental trips, slips, and losing one's way"* (Eslambolchilar et al., 2016, p6). Overall, it is not aiming to propose and validate a new affect model as an extension of existing models, but to step forward from the design space of *Affective Computing* to generate design case studies in an expanded design space considering broader possibilities of bodily experiences. The role of *Affective Computing* in my research is a source of inspiration of technologies I drew on to make design artefacts that cultivate affective experiences through the body.

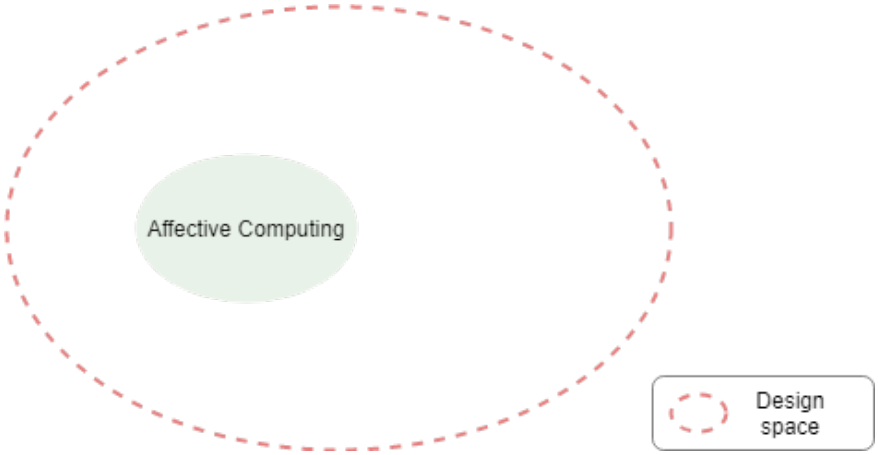

Fig 2.1.5 The Design space: expanded from Affective Computing to a broader area studying affective experiences.

2.2 Somaesthetics: The Concept and Existing Design Practices

Upon expanding the design space of my research from *Affective Computing*, it is important to explore research areas that studied not only emotional responses but also perceptual experiences of the body. *Somaesthetics*, as proposed and frameworked by Shusterman (1999), is a discipline that studies *"the experience of the soma—the perceptual quality of the body over time"*. In this section I will review Shustman's definition of Somaesthetics and the theoretical background of his proposal of the discipline that studies Somaesthetics experiences. Specifically, I will review existing design practices for somaesthetic experiences regarding the design context, technology and bodily practices been explored in making the design artefacts, and their inspiration for my own design practices (to be included in Chapter 4 and 5).

Historically, the study of *somaesthetics* focused on the body's aesthetic functioning, its potential experiencing and appreciation. Shusterman (1999) argued this aesthetic potential is not only unfolded when seeing body as an object--from sensory perceptions or representations inside out of the body when we see the body from an audience's perspective, but also exists when seeing the body as a sensory medium. Such aesthetic appreciation co-exists with sensory perceptions from the body within, which are attractive and delightful in everyday life (refer to the 1884 remark of Jean-Marie Guyau, the once renowned author of Les problemes de l'esthe'tique contemporaine: *"To breathe deeply, sensing how one's blood is purified through its contact with the air and how one's whole circulatory system takes on new activity and strength, this is truly an almost intoxicating delight whose aesthetic value can hardly be*

denied." (cited in Shusterman, 1999)) As an extension to the meaning of the aesthetic appreciation of body, Shusterman's work followed Baumgarten's philosophical text of *Aesthetica* (cited in Shusterman, 1999) which extended the scope of aesthetics from appreciation of artworks to enhancing personal experience of living. Shusterman's research interest in *Somasthetics* is thus inspired by what Baumgarten proposed as *Cultivation of the Body (cited in* Shusterman, 1999*)*, which in particular aims to engender practices that enhance positive bodily experiences. While *Affective Computing* focuses on emotional experiences based on pre-identified patterns appeared on human bodies, *Somaesthetics* provides a perspective that appreciates the aesthetic potential of *soma*, and a framework and methodology for conducting research practices on cultivating aesthetic experiences of the body.

Existing practical studies of somaesthetics focus on bodily experiences caused by emotional responses, physical reaction, and so forth that not limited to affective experiences recognised by the affective models adapted by *Affective Computing* studies. With a purpose of designing technology applications to cultivate the aesthetic appreciation of bodily experiences, Höök et al. (2016) proposed *Somaesthetics Appreciation* design with studies that focused on enhancing 'inward-focusing' bodily experiences, such as awareness and appreciation of body signals, movements and feelings with an augmented environment. Example design studies in *Somaesthetics Appreciation (*Höök et al., 2016) include *Sonic Cradle* (Vidyarthi et al. 2012), *Soma Mat* and *Breathing Light (*Stahl et al., 2016)). *Sonic Cradle* is a dark chamber where users actively interact with the soundscape by altering their breathing to foster user engagement to mindfulness meditation. Vidyarthi et al. (2012) found out that users had mindfulness experience through *Media Immersion*, where the dark chamber, the audiovisual responses towards user breathing enhanced users' awareness of the feeling of their body (for example, the sensations towards the body when inhale or exhale towards the soundscape of *Sonic Cradle*). Höök et al. (2015) also referred to their team's design practices of *Soma Mat* and *Breathing Light* in their proposal of *Somaesthetic Appreciation* design. In designing for *Soma Mat* and *Breathing Light*, Stahl et al. (2016) believed that *"To improve our somaesthetic appreciation, we need to shift out of habitual movements, like when walking, breathing, standing, breaking those patterns to find novel ones"*. Therefore, Stahl et al. took inspiration from the *Feldenkrais* (Feldenkrais, 1987) practice, which involves a number of exercises that are different, sometimes opposite to our habitual movements to increase practitioners' awareness of their body (cited in Stahl et al., 2016). In Moshe Feldenkrais'

introduction of the *Feldenkrais* practices (1987), he provided an example of *"Breathing movements without Breathing"* (p101), which practitioners move their chest while holding their breath. The sensation of blocked breath magnifies practitioners' awareness of their body movements in an everyday activity (i.e. breathing) as holding breath contrasts the usual way of breathing. Stahl et al. (2016) integrated heat pads onto *Soma Mat* to guide users' attention shifts towards different parts of their body. For example, users would be highly aware of the heat at their feet when the Soma Mat generates heat at the foot section. Users would notice the shift of heat stimuli when another section of *Soma Mat* was heated up, which prompted awareness of that part of the body lying on the mat. The sequences of heat stimulation of *Soma Mat* are pre-programmed in a mobile app based on pre-recorded Feldenkrais sessions or Body Scan practices. Similarly, the *Breathing Light (Stahl et al., 2016)* uses light simulation to respond to practitioners' breathing activity. Users interact with the Breathing Light by putting on a belt that detects their breathing pattern. The light mimics and responds toward users' breathing activity so that users enter a feedback loop between the light and their breathing activities. The design of *Soma Mat* and *Breathing Light* inspired my design ideation as it showed a way to augment body sensation (the heat and light sensation of the body) by combining technology (heat pads/dimmable light and mobile app to control the mat/light) and product for everyday body-centred practice (i.e. the mat that could be used as a Yoga mat/the light as an interior lamp).

Fig 2.2.1 From Left to Right: *Soma Mat* (Stahl et al. 2016)*; Breathing Light* (Stahl et al. 2016)*; Sonic Cradle* (Vidyarthi et al. 2012)

As Shusterman (1999) highlighted the sensory perceptions from the body within in somaesthetics, it is important to study bodily experiences from the individuals themselves apart from other people/machine's perceptions. Loke (2013) reviewed studies of technology innovations for body movements and proposed their methodology of 'Moving and Making Strange', which investigates methods of 'making strange' to habitual body movements to enhance bodily experiences and suggesting new perspectives, methods and toolkits to study

bodily experiences. In 'making strange' of existing perspectives of studying bodily experiences (such as embodiment or machine detection of body movements), Loke (2013) proposed to study from three perspectives: the first-person perspective (the practitioner themselves), the traditional third-person perspective (from an observer) and the machine perspective. Examples of 'Moving and Making Strange' include the *Slow Floor* (Feltham & Loke, 2014). *Slow Floor* (Feltham & Loke, 2014) are interactive 'floors' that generate sound effects to reflect users' walking movements during a slow walk. Users of *Slow Floor* are encouraged to react or improvise their walking movements as responses to the sound made by the floorboards. To explore how *Slow Floor* fostered users' awareness and reflection of their bodily experience, Feltham and Loke (2014) evaluated the *Slow Floor* from the observers (who have seen how the Butoh Dancers react and perform on the *Slow Floor*)' perspective and the Butoh Dancers' perspective. The Butoh Dancers reflected their own cultivated awareness of their movements on the floor and their perceptions of full-body experiences, which in *Somaesthetic Appreciation Design* (Höök, 2016), is an inward-focus self-reflecting process. In a similar study of walking sonification *GangKlang,* Hajinejad et al. (2016) mainly took a first-person perspective to investigate walkers' aesthetic experiences of their body movements in walking with the prototype.

As Shusterman stated in his *Somaesthetics* framework (1999), bodily experiences are not separated from their interactions with the environment. Shusterman understands body experience from within, and body experience as interactions with surroundings as a whole instead of a mind-body dualism perspective. Meanwhile, to cultivate attention and awareness of users' bodily experiences, many somaesthetic designs specified boundaries of interactions. In Höök et al. (2015)'s summary of *Somaesthetic Design* case studies, the authors noted that *"in order to achieve a better understanding of your body, you have to actively interfere with your daily unconscious routines and create room for reflection."(p30).* In Vidyarthi et al.' (2012)s design practice for *Sonic Cradle,* they specified *"generating complete engagement without simultaneously providing new sources of distraction"* as their major design challenge. Therefore, Vidyarthi (2012) and their design team created the dark chamber to reinforce Media Immersion (immersive experiences driven by media) and to reduce distractions from the sources other than the interactions provided by *Sonic Cradle*. The *Soma Mat (Stahl et al., 2016)* draws users' attention to the parts of their body within the boundary of the mat. The heat stimulation effectively reduces users' attention to other parts of the body (that located on inactive heat pads) or other interactions from the surroundings. The *Breathing Light (Stahl et*

al., 2016) includes a lamp-shaped top and tassel curtain to enhance an immersive experience with the dimmable light responding to users' breathing patterns. The dark chamber for *Sonic Cradle*, the mat for *Soma Mat* and the lamp for *Breathing Light* helped configure the surrounding environment, while participants were guided to focus on their self-awareness of body within the boundaries. In particular, the lamp and curtains of *Breathing Light* were purposefully installed to *"create(ing) a room within a room, effectively shutting out the external world"* (Höök et al., 2015, p30). However, the sound from outside of the room created by *Breathing Light*, people talking to the participants of *Sonic Cradle* or interactions from other things 'out of the boundary' of *Soma Mat* could be parts of participants' somaesthetic experiences when we expand or eliminate the physical boundaries. To *"create room for reflection"*(Höök et al., 2015, p30) is not about creating physical space that separate the practitioners (of *Feldenkrais*, meditation, *Body Scan* etc.) and interactions from outside of the physical space, but about creating novel experiences that practitioners get into a higher awareness of their body and entering a self-reflection loop. The novel experiences may come from augmented interactions (e.g. the light simulation of the *Breathing Light*) from both the design artefacts and the interactions from the surroundings. With the perspective of seeing interactions from the surroundings as part of our bodily interactions, there is rich opportunity to bring novel perceptive experiences and new perspective of seeing bodily interactions that may otherwise ignored in designing for somaesthetic experiences.

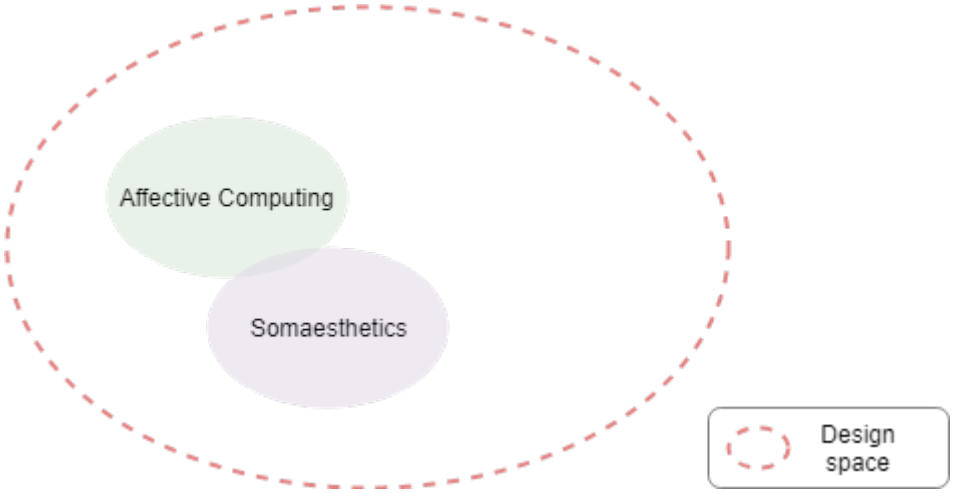

Fig 2.2.2 The expansion of design space upon reviewing Somaesthetics in Section 2.2

2.3 Body-Centred Practices that Incorporate *'Soma'*

2.3.1 Mindfulness Practice

Mindfulness, according to its Buddhist origins and current practical research (MAPPG 2014), is a conscious state of being in the here and now. According to Robert Sharf (cited in Brown et al. 2007), *"the Buddhist term translated into English as 'mindfulness' originates in the Pali term sati and in its Sanskrit counterpart smṛti. Smṛti originally meant 'to remember', 'to recollect', 'to bear in mind'. … [S]ati is an awareness of things in relation to things, and hence an awareness of their relative value."* The Buddhism literature describes Mindfulness as a perceptive state when we are clearer of everything happening around us. Zen practitioners stated that Mindfulness is a conscious state like a mirror, which has high level of clarity of what happens around ourselves. Thich Nhat Hanh (2010), a Vietnamese Buddhist monk and mindfulness practitioner, introduced mindfulness-based practices that bring one's attention to observing, knowing and accepting every object, event and thought in the current moment. By re-focusing on bodily sensation, movement and what is happening in the here and now, practitioners discover a deep feeling of their own bodies, focusing fully on the moment and avoiding dwelling on distress or unpleasant thoughts. To achieve this state of being, Thich Nhat Hanh introduced a number of Buddhist practices to everyday activities with body-centred techniques, such as paying attention to balanced breathing and doing things in a perceptive mode (2010). Later *Mindfulness* was introduced into many clinical and psychological practices based on different understandings of what Mindfulness is. Van Dam et al.(2017) reviewed a number of mindfulness practices and noted that *"there is neither one universally accepted technical definition of "mindfulness" nor any broad agreement about detailed aspects of the underlying concept to which it refers (cited in Van Dam et al., 2017, p3)"*. According to Van Dam (2017)'s summary of mindfulness concept and contexts adapted in different practices, some common factors of mindfulness include attentiveness of current moment and awareness, while other factors adapted in individual practices include acceptance, observing and no value judgments. In clinical practice, mindfulness has become popular as it encourages a non-judgmental emotional state, enhancing practitioners' emotional resilience (Davis & Hayes 2011). Recent clinical research (Claessens 2009) suggests that mindfulness-based practices can reduce one's suffering of pain, stress and depression. Mindfulness practices in clinical settings are usually based on existing therapies, such as mindfulness-based cognitive therapy (MBCT) (Segal et al., 2002), that are targeted

specifically to build emotional resilience for people with depression. Jon Kabat-Zinn defined mindfulness as *"the awareness that arises by paying attention on purpose, in the present moment, and non-judgmentally (2013, p413)."* Kabat-Zinn proposed a six-step practice – mindfulness-based stress reduction (MBSR) – that promotes the cultivation of bodily affective experience throughout the practice (1990). MBSR includes a number of body-centred practices such as the *Body Scan*[1] and *Walking Meditation* (which I will discuss in greater depth later). MBCT and MBSR require a learning process, with specific activities and/or a setting tailored for mindfulness practice. For example, the *Body Scan* in MBSR asks practitioners to *"systematically and intentionally moving our attention through the body, attending to the various sensations in the different regions"* (Kabat-Zinn, 2005, p1). In such practice, one needs to follow an instructor to perform a designed sequence of activities, which requires a certain time, space and the presence of a mindfulness professional. This has limited the accessibility to mindfulness practice, which probably makes practitioners perceive it as a task to complete instead of a relaxation activity one could do at any time.

To bring mindfulness to people who want to practice it in everyday activities, 21awake designed and produced the Buddhify2 app based on mindfulness practices (21awake 2014) to bring it to the public. It allows users to choose their stress stimulus and suggest meditative tasks accordingly. Similarly, *Headspace* (Headspace inc. 2015) allows users to follow a series of mindfulness practices during their spare time. However, users may feel more stressed in the process of making their choices. Also, it may raise doubt around the effectiveness of the suggestions, as the app itself does not take in any objective data.

[1] Body Scan (Kabat-Zinn, 2005) is a systematic practice that practitioners apply high attentions to the bodily experiences at different parts of the body in a sequence.

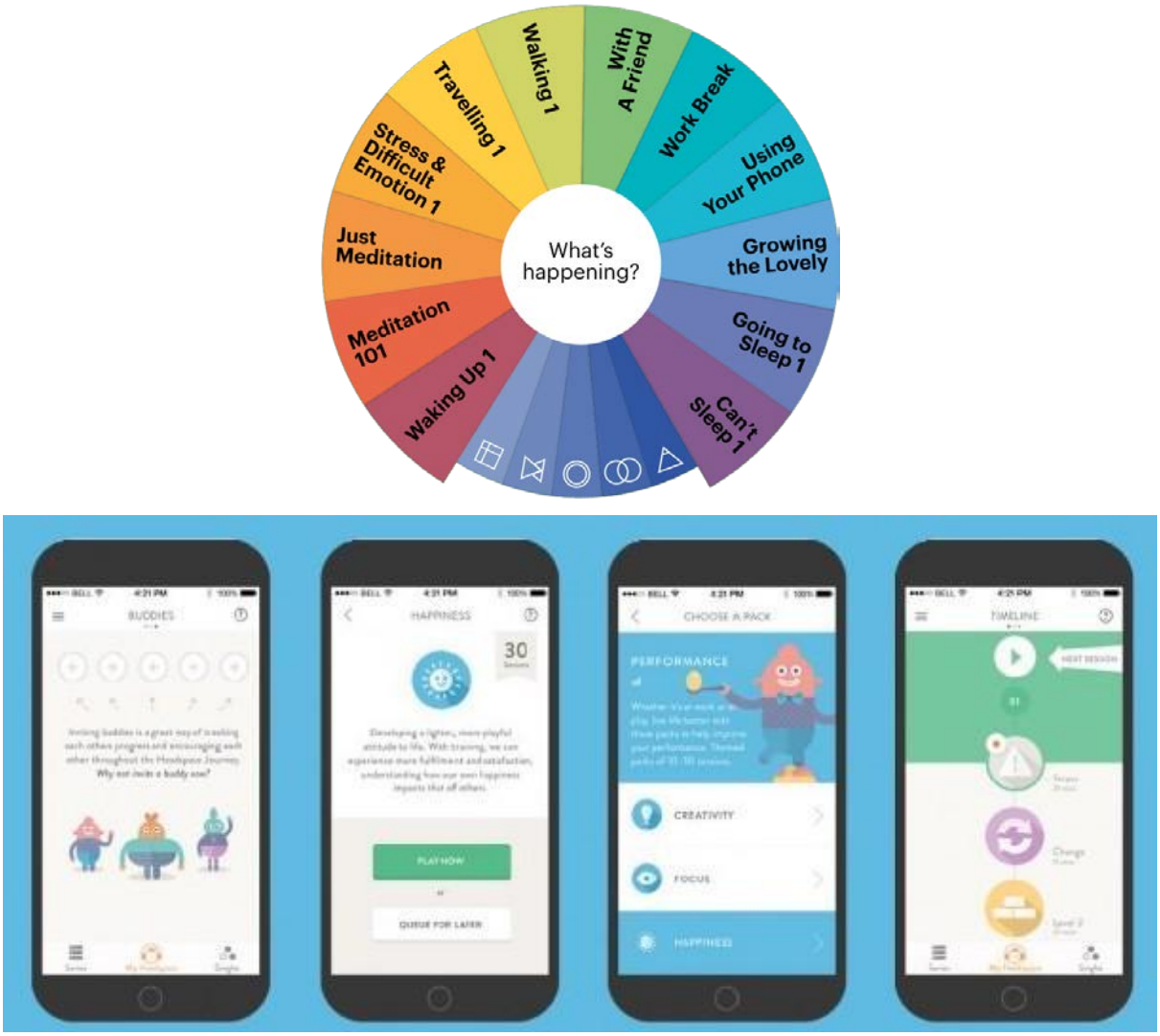

Fig. 2.3.1.1 (Top) The Wheel of *Buddhify2* app: users select the mode based on their situation (Bottom) The interface for *Headspace*, an app for Mindfulness practice.

While mindfulness became popular when many clinical research provided evidences on stress relief, rehabilitation and building resilience, researchers started to question the root of mindfulness definition, the practice/training techniques being introduced and methodology of clinical mindfulness studies. Van Dam et al. (2018) published a critical review on the current research agenda of Mindfulness that discussed the conflicting theoretical origins that existing mindfulness practices are derived from, and some counter-evidences for the effectiveness of Mindfulness in cultivating health and wellbeing. When Mindfulness was introduced as a clinical practice, Kabat-Zinn understood mindfulness from a scientific context where Mindfulness experience would be reinforced by following systematic, scientific-proven practices (Van Dam et al., 2018). Mindfulness in its Buddhism origin is a state of clarity of things happening around us, and observing them as they come and go at the current moment

without dwelling on any of them. The definition of 'without value judgment' was highlighted by Mindfulness professionals in their training and practice to reinforce the 'perceptive' state of mind and reduce the dwelling thoughts (van Dam et al., 2018). However, what comes as 'value judgement' and whether 'no value judgment' is achievable are questions one can raise for current Mindfulness practices. Whether we see MBCT, MBSR or Mindfulness apps, they are all based on a set of pre-established practices (such as body scan). The teaching of these practices may imply the thoughts like 'participants shall follow this particular procedure to achieve Mindfulness state'. While I practice MBSR following Kabat Zinn's instructions as an autobiographical practice, I find myself more focused on how my body feels at the current moment, yet at some moments I wonder 'whether I am doing my body scan in the right way' or 'would other ways, such as listening to music, be able to help us achieve Mindfulness'? These moments would involve value judgments when we started wondering the right or wrong ways of doing mindfulness practice.

Although there is limited evidence regarding the effectiveness of Mindfulness practices, some media articles reported their writers' opinions and negative experiences with Mindfulness practices. Tayana Simons (2015) shared her opinions on limitations of Mindfulness and her negative experiences with existing mindfulness practices in her HuffPost blog, stated that clinical Mindfulness practices which disregarded the specific conditions of patients were irresponsible. In Dawn Foster's article on The Guardian (2016), she mentioned about a Mindfulness practitioner--Claire's experience with the mindfulness training programme as *"Initially, I found it relaxing,"..."but then I found I felt completely zoned out while doing it. Within two or three hours of later sessions, I was starting to really, really panic."* Dawn (2016) has also posted about her own panicking experience with mindful eating and meditation *"We're told to close our eyes and think about our bodies in relation to the chair, the floor, the room...But there's one small catch: I can't breathe…it feels as though my lungs are sealed...I feel a rising panic and worry that I might pass out...For days afterwards, I feel on edge. I have a permanent tension headache and I jump at the slightest unexpected noise."* Wilson et al. (2015) found out that Mindfulness meditation increased the likelihood of obtaining false-memory. In Wilson et al's (2015) first two experiments, participants were instructed to practice breath focusing (a Mindfulness practice) and "mind-wandering" (i.e. "to think about whatever came to mind") after studied lists of semantically-related words. Result unveiled that participants who have done Mindfulness practices have higher potentials to provide answers not included in their studies of the paradigm. When Wilson et al. (2015)

investigated Mindfulness practice's effect on memories with a reality-monitoring paradigm, participants remembered less accurate real-life events after their Mindfulness sessions. Most clinical evidences of positive effects of mindfulness practices came from clinical studies with Neuroimaging (e.g. MRI analysis), quantitative psychological screenings and/or self-reporting. These research methods, according to Van Dam et al. (2018)'s review, have limitations that lead to the exaggerated effects of Mindfulness in stress and depression rehabilitation.

When considering Mindfulness from its origin, it is possible to see how it can be achieved in many ways other than the therapeutic Mindfulness practices. In my own experience, actively sensing and perceiving my bodily experiences in daily activities such as sitting and walking could enhance my Mindfulness experience as they increased my awareness of my body in the current moment without thinking of its value (e.g. whether it is good or bad feeling). Mindfulness is a state of being which not only achievable by systematic practices such as Kabat-Zinn's MBSR, but also achievable in our daily activities such as sitting, walking and listening to music as long as the practitioners obtained strong awareness of the 'here and now'. When we see mindfulness practices beyond the scientific context, it offers the creative potential of cultivating novel, stronger, interesting bodily experiences in everyday life. In HCI design practices, Thieme's *Spheres of Wellbeing* (2012) provided a good example of combining visual representations and biophysical sensing technology to help vulnerable women practice mindfulness. While few research was done in the context of Mindfulness with creative practice, the design of *Spheres of wellbeing* inspired me to explore combining audio/visual feedbacks and biophysical sensors to cultivate Mindfulness experience in everyday activities that encourages open-ended expressions and reflections of users' bodily experiences.

Therefore, in my doctoral research, I would not design for Mindfulness and evaluate its effectiveness in a clinical context. Instead, my research expanded the exploration of design and making into a broader context, in which engagement with the 'here and now' was engaged in experiences with creative mediums.

Upon reviewing Mindfulness definition and existing practices, my design practice will not suggest 'a better way to practice mindfulness' or combining digital art and design with existing mindfulness practices. Instead, my design practice will explore somaesthetic

experiences in an everyday practice that stimulate our awareness of our body, while mindfulness practice is one of the many practices that fosters body awareness. Mindfulness practices mentioned in this section are rather positioned as design sources that inspired my making of design artefacts. Instead of adapting clinical Mindfulness practices or the functions in Mindfulness applications, my design practices will look back to the Buddhism literature of Mindfulness practices that aims to foster our attention and awareness of the 'here and now'. I took walking as my specific design context of everyday practice, for which there is also a Buddhist Mindfulness practice named *Walking Meditation* (Nhat Hanh, 2007). I will create audio-visual interactions that are concerned to cultivate the 'perceptive' state of mind. Instead of creating a boundary for immersive experience, my design practices will begin with exploring engaging bodily experiences in the 'open air', where walking again is a suitable context as walking activity can be created without a physical boundary.

Apart from existing Mindfulness practices, I also investigated creative practices that potentially cultivate our awareness and perceptive bodily experiences in everyday settings in the rationale of creative art and music making. In Section 2.3.2 I will review *Deep Listening* (Oliveros, 1980) as an example creative practice by musicians that cultivates practitioners' bodily experiences via creative listening practices.

2.3.2 Deep Listening

Deep Listening is an artistic listening practice that encourages deep perception – an expansion of perception in as many modalities as possible – of the ongoing space/time continuum via active listening and imagining. In the 1980s, Oliveros introduced *Deep Listening* practice as an augmented listening practice for music improvisation. She speaks of hearing as the *"primary sense organ,"* and has summarized Deep Listening as follows:

Deep Listening is listening in every possible way to everything possible to hear no matter what you are doing. Such intense listening includes the sounds of daily life, of nature, or one's own thoughts as well as musical sounds. (Osborne 2000, p.1)[2]

In other words, *Deep Listening* fosters one's awareness, perception and understanding of sounds within a certain period of time and/or space to achieve a holistic listening experience (Oliveros, 2005). Oliveros found out Deep Listening as a practice to create new listening experiences from meditation practices that foster practitioners' awareness. (Oliveros,

[2] This quote was directly quoted from Osborne's article at http://www.osborne-conant.org/oliveros.htm

Software of People). To practice *Deep Listening*, one *"ought to be able to target a sound or sequence of sounds as a focus within the space/time continuum and to perceive the detail or trajectory of the sound or sequence of sounds. Such focus should always return to, or be within the whole of the space/time continuum"* (Oliveros 2005, p.xxiii). The listening and sound-making practices in *Deep Listening* form a loop which practitioners listen and remembering present sounds from their body and surroundings, then actively imagine and making sounds with their body and bodily interactions towards the surroundings.

In Oliveros's (2005) body-involved *Deep Listening* practices, the focus is on enhancing four levels of bodily experience: *sensation, perception, intuition* and *thinking.* For Oliveros, *Sensation* refers to physical senses from the body, such as the projection of an object in your eyes, the sound signal received in your ear and the muscle tension in your feet. *Perception* refers to the understanding of a perceived object or event, such as feeling of touch and guessing the location of sound source. *Intuition* and *thinking* are highly related to cognition of bodily sensation and perception, which refer to the willing of an act and rational understanding according to one's bodily sensation and recognition (2005). For example, in Flower Breathing practice, Oliveros (2005) suggested practitioners to position their hands in the shape of a flower and to imagine the scent of flowers. Oliveros (2005) also introduced a number of *Deep Listening* practices that not only suggest a focus on the ongoing sound from the surrounding environment, but also encourage attentions to the practitioners' embodied experiences such as sensation, body movement and mood. *Deep Listening* can be integrated in body-centred practices that focus on cultivating somaesthetic experiences. For example, in *slow walk* (Oliveros, 2005), practitioners are not only instructed to focus on group members' moves, but also encouraged to pay attention on their slow-motion body movements while performing an extremely slow walk that magnifies the sensation of the body. In Oliveros' (2005) *Deep Listening* practices, breathing encourages a strong focus on the changes of muscle tension and air pressure of the inhalation and exhalation, the perception of the strength and liveness of the breathing and thoughts occurring during the practice. For example, in *Breath Improvisation (Oliveros, 2005),* practitioners are instructed to pay attention and creatively play with the lengths of inhales and exhales. By doing so, practitioners reflect and improvise their breath like composing a piece of music. The improvisation of breathing would cultivate practitioners' body sensation of filling in, holding and empty out the air in their lungs, perception of the acoustic features of the breathing sound, intuition and thinking of further 'composition' of their breath.

Mindfulness practices inspired my design ideation in providing example practices that enhance our bodily experiences in terms of increasing our awareness of the current moment while minimizing our dwelling thoughts. *Deep Listening*, with inspiration from Oliveros' (2005) interest of Buddhism meditation, mindfulness and other relaxation practices, provided a creative way of cultivate somaesthetic experiences. With *Deep Listening*, practitioners not only maintain high awareness of their body, but also express their perception of their body by active listening, reflecting and improvising sound. The expression of body experiences provides a playful experience that fosters practitioners' aesthetic perception of their body. Therefore, my design space (see Fig 2.3.2.1 below) for this research expands by combining body-centred practice that fosters awareness of our body and creative self-expression for enhanced somaesthetic experience, taking inspiration from *Mindfulness* and *Deep Listening*.

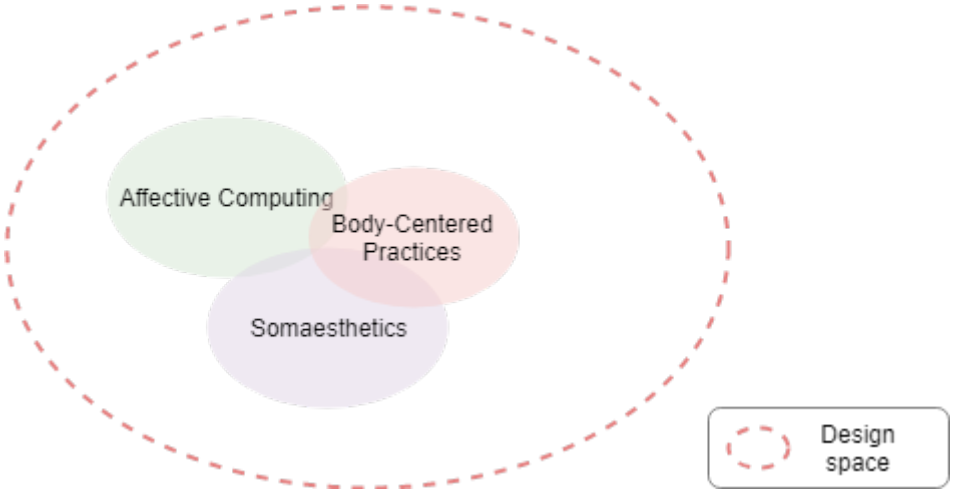

Fig 2.3.2.1 The expanded design space with Body-centered practices such as Mindfulness and Deep Listening.

2.4 Creative Art and HCI Practices for Somaesthetic Experiences

Recent HCI research has begun to study a wider repertoire of body movements in studying bodily experiences. A number of HCI researchers and Artists have investigated bodily experiences to form their design knowledge of somatic-based interaction design (Schiphorst 2009a; Schiphorst 2011; Höök et al. 2015). In pragmatic studies of *somaesthetics*, researchers look into bodily experiences in a number of body-mind disciplines (such as Feldenkrais and the Alexander technique (Höök et al. 2016)) and choreographic performances (e.g. dance (Feltham & Loke 2014) and stage performance (Svanaes & Solheim, 2016). In creative art practices, Schiphorst (2009b) highlighted the importance of studying *somaesthetics* through

art and design practices to foster self-expression and self-reflection in creative ways. Schiphorst created art installations combining visual art, sound, materials and sensor technologies to enhance users' awareness of body activities. For *exhale* (Schiphorst, 2005), Schiphorst and her group made a skirt that senses users' body movements, with sound and vibrations as responsive feedbacks to foster users' self-reflection of their breathing. The skirt allowed users to 'wear their breath' which added another layer of sensational and perceptual experience of the breathing body. Another design study *soft(n)* (Schiphorst, 2009a) explored somaesthetic design with creative expression of body movements by touch. Schiphorst's (2009a) group created a number of soft objects with force sensing pads to detect a number of touch movements (e.g. slap, hold, knock, etc.) and various feedback mechanism e.g. LED lights and speakers to trigger users' touch expressions. However, few studies have looked into how these disciplines cultivate somaesthetic experience in everyday practices, such as sitting and walking, to foster novel, pleasurable experiences over familiar, mundane activities.

A number of HCI design studies have explored *somaesthetics* to augment body awareness in mindfulness practices. Through *Spheres of wellbeing* (Thieme et al. 2013) users can see the responsive visual feedback of their biophysical activities (e.g. heartbeats). This ambient responsive mechanism was used as a creative and effective way for self-reflection, self-regulation and empathy-enhancement towards the affective arousal from the user's body. In *Sonic Cradle* (Vidyarthi et al. 2012) one can sit still, breath to the responsive meditative sound and immerse in a relaxing practice. *Somaesthetics* can also be seen in movement-based body-centered practices. For example, people could feel the heat at different parts of their bodies on the *Soma Mat* (Höök et al. 2016). Such heat sensations in their bodies are seen as a somaesthetic experience that affects people's body movements unconsciously to cultivate their engagement in the Feldenkrais exercise (Höök et al. 2016). *Sonic Cradle*, *Soma Mat* and *Breathing Light* inspired me with combining creative audio/visual representations and biophysical sensing technology to enhance somaesthetic experience by immersively engaging body-centred practices (such as meditation and Feldenkrais), while I would like to take these techniques into creating applications that fosters such experience in everyday activities that people are familiar with and have access to at any time. Instead of letting users engaging with bodily experiences such as the body scan or Feldenkrais, my design artefacts would encourage users' free exploration of body sensations, perceptions and reflections. The users will not be instructed to follow a specific attention procedure (like in *Soma Mat* users follow a specific program to focus on their body experiences accordingly). The design artefacts in my

research will be present as not only ‘a mirror’ that reflect users’ bodily experiences, but also a medium to foster their attention or to provide novel experiences towards habitual, mundane body activities (such as the strength of breathing and/or speed of walking).

In Section 2.5, I will introduce two digital art inspired methods, data visualisation and data sonification, for fostering user engagement to novel experiences towards body activities. I will also discuss about my selection of data visualisation and sonification in the design context of my research.

2.5 Digital Art to Express Somatic Experiences

To bring users’ attention to their bodily movements, HCI researchers have explored creative data representation approaches to extend users’ sensory experience of their biophysical performance and interactions from outwards. Data visualisation and sonification are two widely used methods in scientific research to significantly enhance one’s perception of complex data and/or events (Zhao et al. 2008). In this section I will introduce the concepts of Data Visualisation and Sonification, how they were used in the context of *Somaesthetics Design* and how we could apply these methods in designing for somaesthetic experiences.

2.5.1 Visualisation of Data with Graphics and/or Machine Movements

Data Visualisation refers to the representation of data through visual patterns, metaphors and objects (Few 2013). It aims to cultivate the communication between the viewer and the owners/subjects of the data. *Data Visualisation* creates graphical representations that not only illustrate the data accurately, but also unveils the meanings behind the data by enabling users to perceptually interrogate the data set (Ziemkiewicz & Kosara 2008). *Affective Computing* applications used *Data Visualisation* to illustrate users’ emotional experiences in a straightforward way. For example, Affectiva (2015)’s *AffdexMe* app adapted straightforward data visualization technique, with horizontal bars denoting the likelihood of six basic emotions of each facial expression. In my own experience with the *AffdexMe* (2015) app, the visualisation made me aware of my emotions on the informatic level, yet it hardly create engaging experiences that I would respond to ((e.g. I am ‘60% happy and 20% contempt’ according to the on-screen visualisation, while I don’t feel anything about it. Sometimes I wonder ‘is it so?’ for the detection results.). Unlike the straightforward data visualisation widely used in *AffdexMe*, Khut (2016) used dynamic shapes (i.e. circles that change sizes and

colours over time) in his art installation *Cardiomorphologies* to respond to participants' breath and heartbeats. The dynamic shapes of *Cardiomorphologies* (Khut, 2016) not only made participants aware of the intensity and frequency of their breathing and heart-beating, but also triggered participants aesthetic perception of their body movements during their interactions. Participants may obtain different levels of attention (e.g. with relaxed attention or alerted attention) to the dynamic visualisation that led to different physical and emotional experiences of their body movements. Apart from using computer graphics as data visualisation method, artists and HCI designers have also explored using physical movements of various materials to mimic and/or respond to participants' body activities. For example, Simbelis et al. (2013) created *Metaphone* to express users' emotional arousal and body movements by machine drawing with different colours and strokes. Lozano-Hemmer (2008) programed and installed pulsing lights on the ceiling of the *pulse room* to mimic participants' heart beats. When a participant entered the *pulse room*, he/she holds the handle at the entrance that detects their heartbeats. The light bulbs on the ceiling pulsed according to the heart rate detected by the handle. When another participant entered and held the handle, the lights changed its pulsing frequency to reflect the heart beats of the new participant (Lozano-Hemmer, 2008). The pulsing lights not only made participants aware and increased their aesthetic perception of their heartbeats, but also generated communications among the participants through perceiving light pulses mimicking another participant's heartbeats. Long and Vines (2013) used vibrations of water in *Mindpool* to visualise participants' brain activities. In making of the *Mindpool*, Long and Vines *(2013)* installed a number of vibration motors at the bottom of the pool to represent different channels of EEG data relating to various brain activities. Participants perceive the aesthetics of their brain activities through the reflective water vibrations in the pool and obtain higher awareness of their affective experiences associated with brainwaves.

Fig. 2.5.1a. Digital art installations that explore embodiment and the expression of bodily activities.
Left: George Khut, *Cardiomorphologies*, 2007; Right: Lancel & Maat, *E.E.G Kiss, 2014*

Fig. 2.5.1b. Digital art installations that explore embodiment and the expression of bodily activities.
Left: Lozano-Hemmer, Pulse Room, exhibited in Seoul, 2008; Right: Long & Vines, *Mindpool*, 2013,

2.5.2 Data Sonification

Data Sonification is introduced as a complementary method to visual interfaces, featuring a sonic representation of temporal/spatial information with various acoustic properties such as pitch, rhythm, volume, etc. It aims to provide an augmented listening experience for the users during their interaction with computer systems (Pauletto et al. 2016). The use of *Data Sonification* enhances their awareness of the information delivered through the sound patterns or soundscape mapping with the data. This section will discuss the concept of Data Sonification and its application in HCI and art practices.

With *Data Sonification*, one can hear the information about analysed data and the interaction process according to the acoustic timeline, which is, according to Hermann et al. (2011), is helpful for users to notice the patterns of sonified objects or actions, and to perform their reactions accordingly. Regarding the cultivation of bodily experience, Parkinson and Tanaka (2014) suggested that sonification could be a method to *"extend the affective capacities of the listener and allow an embodied experience of the data and the phenomenon behind the data"* (pages 151-152). By listening to the sonified data, one can get a stronger perception and/or feeling to the information behind the sound and potentially to act towards the sonification. For example, in Watashima's 'Ah' (2012), the device responded to the users with 'ah' in various tones according to the touching/stretching force. From the video documentation of 'Ah' (Watashima, 2012), users could tell 'the feeling of the device' as excited or painful when they mapped various tones and lengths of 'ah' with their understandings of emotional responses. For example, when a user touched the 'Ah' device gently, the device responded with a long

‘ah’ sound with lower tone. Such response from the device was understood as ‘enjoyable’ or ‘relaxed’ by the users.

Fig. 2.5.2 Kenta Watashima's 'Ah' (2012): A touch-sensitive device with sonification of touch force.

In designing feedback mechanism of data sonification, Hunt et al. (2004, cited in Hermann et al. 2011) highlighted that the generated sonic feedbacks creates signals to trigger continuous user interactions. For example, in Hajneijad et al. (2016)’s *GangKlang*, responsive sonic feedbacks are generated by the app when users walk, while users could manipulate their walking movements to alter the sonic feedbacks. In designing data sonification for physical activities, Turchet and Bresin (2015) have referred to various sonification mechanisms such as varied intensities, pitch and rhythm to indicate different physical states that successfully augmented users’ awareness by distinguishing their walking experience at various emotional moments. Moreover, Franěk et al. (2014) explored the synchronisation between music tempo and walking pace by using a list of songs with different tempos at their chosen routes. In Franěk et al. (2014)’s user study, participants are likely to walk towards the music tempo comparing to participants who did not listen to music while walking on the same chosen routes. The finding of Franěk et al. (2014)’s study inspired me that changing music tempo may influence our perception of the connection between acoustic feedback and our body movements.

2.5.3 Applying Data Visualisation and Sonification in Different Contexts

Data Visualisation and *Data Sonification* have their own benefits and limitations depending on the context of our interactions. When we expect a direct message derived from the data, an aesthetic and immersive experience with the data or a perceptual process towards the data without interrupting our listening experience, *Data Visualisation* is more suitable as a visual representation that is more direct and cultivates higher attention towards the data itself. For example, for *Cardiomorphologies* (Khut, 2016) and *E.E.G Kiss* (Lancel & Maat, 2014), the visualisations provided beautiful, reflective and metaphoric experiences for participants who sit/stand still and being immersed in the environment created by the installations. However, in contexts requiring high attention to ongoing activities e.g. walking and running, visual presentation of biophysical data might distract users from their activities. For example, reading data plots while walking will increase users' cognitive load that may result in lower awareness of their ongoing practice. *Data Sonification* may be less intrusive in communicating about changes, amplitudes and dynamic movements of walking. For example, in designing for *GangKlang*, Hajneijad et al. (2016) used sonification of walking so that users could reflect their walking activities by listening to the soundscape while keeping their eyes on the surroundings. The decision of whether to take *Data Visualisation* or *Data Sonification* as the main approach of an application depends on the context of the design project, the kind of activities one expects the users to engage with, and the kind of bodily experiences the designers aim to generate for the users.

In this research, *Data Sonification* was used as the major feedback mechanism to engage user's attention and provoke their affective experiences towards their bodily sensations, intuition and thoughts throughout their body-centred practices. *Data Visualisation* will also be applied as a simple and straightforward interpretation of body data (e.g. when users would like to reflect their walking experiences by checking the visual interface or to find out whether the data is recorded accurately) yet it will not be the dominant modality of interaction during the practice.

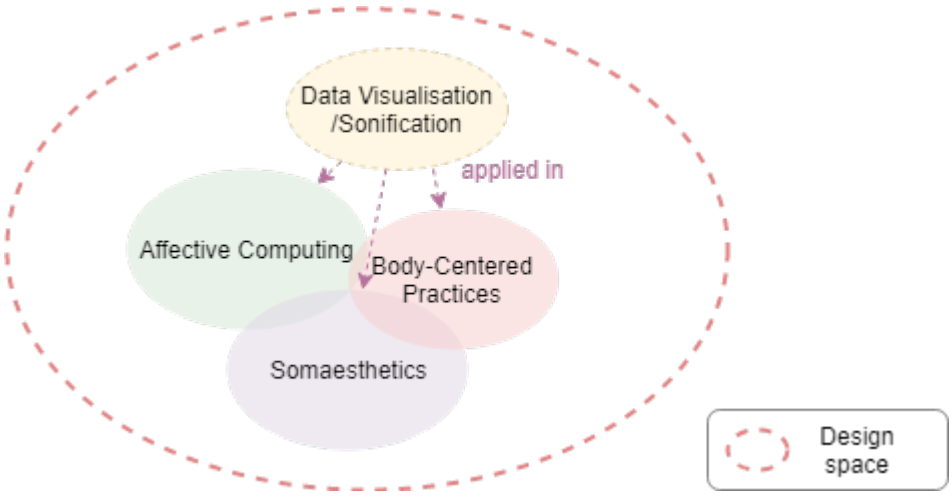

Fig 2.5.3 The design space redefined at the end of Section 2.5

2.6 Summary of Chapter 2

In this chapter I reviewed the theories and concepts that inspired my design practices and illustrated the formation and expansion of the dimensions and territories of the design space. In Section 2.1 I provided a critical review of *Affective Computing* based on Picard (1997)'s answers to major challenges and her vision of this area. The review also covered the realisation of limitation in existing affective models and the potentials of designing in the expanded territory based on a broader understanding of *affect* and how this exploration entered the area of somaesthetics. In Section 2.2 I reviewed the concept and practices of *Somaesthetics*, including Shusterman (1999)'s proposal of *Somaesthetics* with his particular interest of developing 'practices to cultivate the body' and a number of HCI and art practices to enhance *Somaesthetics* experiences in terms of the key concepts and beliefs of Somaesthetics Design (Höök et al., 2015), the body-centred practices they took inspirations from and how these practices inspired my design practices. In Section 2.3 I critically reviewed two body-centred practices, *Mindfulness* and *Deep Listening*, which inspired my design ideation yet not positioned as my design purposes. In Section 2.4 I reviewed existing case studies of mindfulness apps, somaesthetic design and creative art practices to enhance body-centred practices. And in Section 2.5 I discussed *Data Visualisation* and *Data Sonification* as creative techniques to represent body data and to create responsive interactions that foster our bodily experiences in walking. As my research aimed to unfold potential 'new knowledge' in the extended territory, I drew upon the *Research through Design* (Frayling, 1993) approach, which will be discussed in detail in Chapter 3.

Chapter 3: Integrating Data-Driven Digital Art in Somaesthetic Design: a Research through Design Exploration

In this chapter I describe the methodology that I have devised for this research, incorporating *Research through Design* (RtD) as a general approach guiding my exploratory design practices and the applied methods been used at different stages of the project. As described in Chapter 2, my research aim and design purpose is to explore designing for enhancing somaesthetic experiences in everyday walking, with digital art practices and biophysical technology. Based on the review of *Affective Computing* and somaesthetic theories, body-centred practices such as mindfulness and deep listening, existing HCI design practices for bodily experiences, I made design artefacts integrating biophysical sensing technology and digital art practices to foster users' somaesthetic experience in walking activities. The artefacts developed in this research, along with the making process, will be discussed in terms of how the design artefacts were presented in the extended design territory identified in Chapter 2, and how digital art could be applied in HCI design for somaesthetic experience. The user studies of the design artefacts will not only illuminate how HCI design can cultivate somaesthetic experiences integrated in everyday mindfulness practice, but also foster 'new' user experiences that were unexpected, sometimes contradicting the experiences my design artefacts aim to enhance. The discussion of the 'new' user experiences will potentially 'generate new knowledge' within the design process of discovering people's somaesthetic experience in walking. In this chapter, I will discuss how my research and design practice follows the *RtD* approach. The discussion will include a comparison among *Research through Design* and similar approaches (such as *Research into Design*, *Research for Design* (Frayling, 1993) and *Research through Art* (Schiphorst, 2009b), to explain the most appropriate approach for my research. This Chapter will also clarify which *Research through Design* tradition and practices my research is adapting that suits my design context by providing an in-depth review of various traditions of *Research through Design* in different contexts, including *Research through Design* projects from Goldsmiths College Interaction Research studio (e.g. *The Curious Home* (edited by Beaver et al., 2007) and *Datacatcher* (Gaver et al., 2016)), *Critical Design* (Bardzell & Bardzell, 2012), *Research through Design* in making commercial products (Zimmerman et al., 2014) and the constructive practices of *Research through Design* in 'the labs, the fields and the showrooms' (Koskinen et al, 2011). In the end of this chapter I will also introduce practical methods applied in *Research through Design*

(such as making ‘provotypes’(Boer & Donovan, 2012) and *Annotated Portfolio* (Gaver & Bowers 2012)) .

To gain an initial understanding of the bodily experiences affective technology could foster, I practiced and documented my own experiences towards mindfulness practices to collect design sources. After that I deployed ‘provotypes’ (Boer & Donovan, 2012) to refine design ideas and to provide tangible interactive process to actively engage users in technology-augmented somatic activities. The design and prototyping process will also involve collaboration with sound artists. To investigate users’ affective experience provoked by the proposed design practice, interactive exhibitions will be organised to observe users’ activities and bring up open discussion of their provoked experience. For evaluating bodily experiences in long-term practices such as walking meditation, empirical user studies will be conducted. Findings will contribute in either forming concrete design proposals or reflecting the design achievements and issues in this research. The research thesis will be summarized in a form of *Annotated Portfolio* (Gaver & Bowers 2012) to reflect the design process and findings during this research exploration.

Section 3.1 will introduce the general research approach, also as a design paradigm, the *Research through Design* approach. The discussion will introduce the concept and practice of *Research through Design*, with a justification of the relevance of this approach in my research context. Section 3.2 will review various *Research through Design* research practices in different contexts, including *Research through Design* in design studio work, *Critical Design*, *Research through Design* focusing on creative practice element in lab, field and showroom and *Research through Design* for making commercial products to identify suitable *Research through Design* practices for this research. Section 3.3 will discuss the practical methods for delivering artefacts in designing for personal experience, i.e. making ‘provotypes’ (Boer & Donovan, 2012). Section 3.4 will discuss the qualitative methods to openly evaluate user data based on individual contexts. Section 3.5 will introduce using *Annotated Portfolio* and *Strong Concepts* to document, reflect and abstract research findings throughout the concept building, design, making and user evaluation of the practical projects in this research. Section 3.6 will state the ethical concerns and ethical approval obtained for conducting this research.

3.1 Research through Design

Research through Design is a term coined by Christopher Frayling (1993) to position design practices as a way of conducting research. Frayling (1993) categorised three types of 'practice research': materials research that studies the materials used in artistic making; generative practice that makes artefacts to present ideas no one has considered before; and action research to communicate findings from the research and making process (e.g. experiments in the design studio, research diaries and reports). In *Research through Design*, the artefacts, the design and experiment process and the documents produced during the process contribute to delivering new knowledge. In a special issue of the Design Issues journal on the subject (2017), the editors summarised *Research through Design* as a practice that takes making as research, where the making process can also carry new knowledge that contributes to its research area (Brown et al. 2017). They also indicated that design research could address the question of "what it means to make well" (Brown et al. 2017, p.2). In the context of my research, the question of *"what it means to make well"* (Brown et al. 2017, p.2) specifically refers to 'what it means to make something that can cultivate strong bodily experiences'. The insights will not only be derived from the design artefacts I made, but also from the design process (including brainstorming, experimenting different technologies and scenarios, etc.), the users' diary of their engagement with the design artefacts. Hence, considering the subjective and open-ended nature of somaesthetic experiences, this research will take a design approach that is exploratory, sensitive to the affective contexts and supportive to open-evaluation from the participants, that has the potential to suggest new solutions for intervention design with body-centred practices. This can be considered as a *Research through Design* practice.

When Frayling (1993) delivered the disciplinary statement of *Research through Design*, he indicated three different types of practices, *Research into Design*, *Research for Design* and *Research through Design*, regarding the aspects being studied in design practices. *Research into Design* mainly investigates the theoretical aspects of design practices, such as the history, cultural, aesthetic and perceptual qualities of design artefacts. *Research for Design* aims to contribute to the communications of the design artefacts (e.g. how to present a design artefact), sometimes inform future design education and methods. *Research through Design* is not necessarily on contributing to design itself or design education, but using design as a method to generate new knowledge to existing research areas, or areas at the intersection of

existing disciplines that are under-explored (Frayling 1993). As stated in Chapter 2, my research aimed to generate 'new knowledge' with inspirations from existing practices in *Affective Computing*, *Somaesthetic Design* and body-centred practices, and could be positioned in the expanded design space beyond these areas. The 'new knowledge' from my research is not particularly about design education and methods as *Research for Design*. Rather, the 'new knowledge' from my research will provide a possibility to design in the extended landscape of *Affective Computing*, *Somaesthetic design*, Body-centred practices and the application of digital arts (refer to Fig 2.5.2 in Chapter 2). Another similar approach is the *Research through Art* approach applied in Schiphorst's (2009b) research in embodiment and performance. This approach generates new knowledge via art making. Both *Research through Design* and *Research through Art* encourage exploratory practices to generate new knowledge to contribute to new debates or new findings for existing debates. Schiphorst (2009b) saw her practices as *Research through Art* practices as her research focused on *"the design of networked, wearable and tangible technologies that are exhibited as interactive art installations"* (p32). For example, *exhale* (Schiphorst, 2005) was created as an interactive art installation that showcases a possible way to use biophysical sensing technology to enable 'wearing the breath' experience. The presence of *exhale* (Schiphorst, 2005) reflects the artist's expression of their understandings and meaning-making of the connection between breathing and the movements of the fabrics, and a potential way of combining biophysical sensing technology to cultivate people's awareness of body movements while breathing. In Schiphorst's art practices (e.g. *exhale* (2005) and *soft(n)* (2009a)), HCI design practices are positioned as inspirational sources providing concepts (e.g. *Experience-Centred Design* (Wright et al., 2010)), techniques (e.g. interface design) and tools (e.g. biophysical sensor technology). For *Research through Design*, the artefacts were made based on design enquiries following HCI design procedures. For example, Vidyarthi et al. (2012)'s *Sonic Cradle* is created as a design artefact driven by the design goal of enhancing meditative experience for mediated stress management. The making of *Sonic Cradle* includes design ideation such as collecting music for mindfulness from potential users along with objects and material selection (e.g. the use of the hammock) to create the chamber. The evaluation of *Sonic Cradle* involved 15 co-design sessions with laypeople (who are not mindfulness/meditation professionals) that the feedbacks from the participants also influenced further design iterations (Vidyarthi et al., 2012). Art practices for *Sonic Cradle*, are positioned as inspirational source for the design ideation and interactive medium making (e.g. creating the sonification of breathing). The difference between *Research through Art* and *Research*

through Design are how the author/practitioner saw their practices as, and/or the characteristics of the artefacts been made (see Fig 3.1 below).

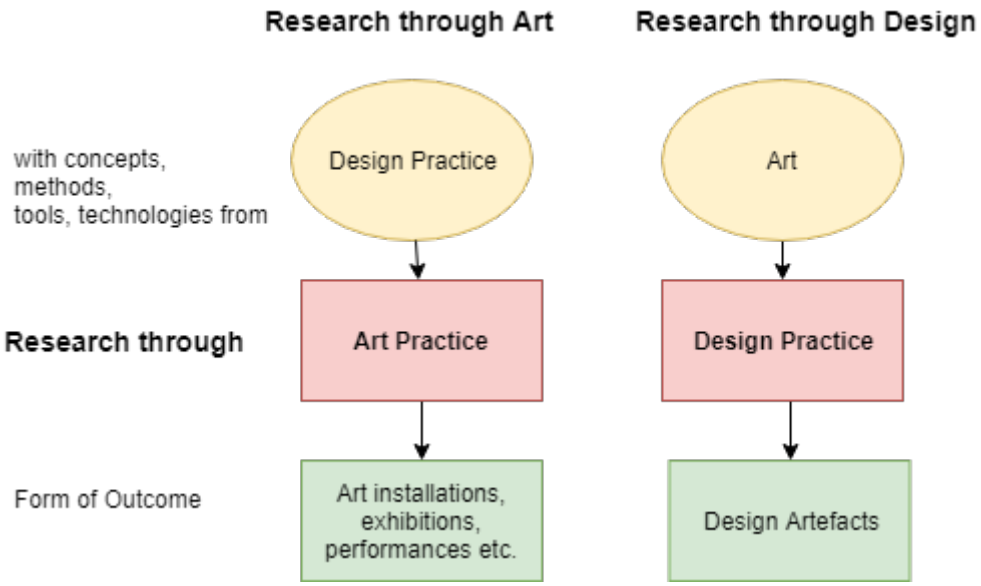

Fig 3.1 The difference between *Research through Art* (referred to Schiphorst, 2009b) and *Research through Design* (Frayling, 1997) in this research, considering the roles Art and Design play in each context.

This research did not follow *Research through Art* approach as the artefacts I made are not seen as artist expressions or performances. Rather, the artefacts would be outcomes from a design process within the design space. My RtD practices were inquiries of making artefacts to cultivate somaesthetic experiences in everyday walking, rather than an art-making processes to express my understanding of somaesthetic experiences. Therefore, *Research through Design* was the most relevant approach to be taken.

3.2 Review of Various Traditions of Research through Design

Research through Design has been developed in various traditions since Frayling articulated the kind of design research that follows this approach, and the outcomes that *Research through Design* would bring. Frayling (1993)'s paper of *Research through Art and Design* positioned various roles design would play in research practices, yet it has not provided clear guidelines about how to conduct *Research through Design* practices (Jonas, 2007). Various HCI researchers (Sengers & Gaver 2006) argue that *Research through Design* seems to engender open-ended, non-reductive approaches and support user's own interpretations and appropriation. In this section, I will review a number of HCI design traditions drawn upon *Research through Design* regarding how designers use theories to inform their making of

design artefacts, what role and purpose the design artefact is taking in each tradition, and which tradition my research is following.

Research through Design has been adapted by design studio practices. In Goldsmith College's Interaction Research studio practices, the designed artefacts are not presented as solutions of design problems, but as tangible mediums to probe new combinations, cross-discipline implementations, or new experiences within the design rationale. For example, *The Curious Home* (edited by Beaver et al., 2007) presented a collection of *Research through Design* practices under the theme of discovering home technologies' potentials of supporting ludic activities (i.e. self-motivated activities such as exploration and reflection). Each practice for *The Curious Home* (edited by Beaver et al., 2007) involves many makings that explore new functions could be integrated in everyday things that triggers users' curiosity and active exploration. For example, Gaver et al.'s *Drift Table* (2004) involves design innovations such as exploring home objects (i.e. the table), interactive technology (i.e. the display screen and sensor embedded in the table) and a number of sources of images from outside of the home environment (i.e. the aerial photographs). Instead of an evaluation according to a hypothesis, *Drift Table* (Gaver et al., 2004) explores the potential user reactions to a novel design prototype, and the exploratory findings of achievements and issues will inform future design for ludic activities. Another design practice under the theme of *The Curious Home*, *Local Barometers* (Gaver et al., 2008), aimed to provide novel user experiences by connecting social conditions of the neighbourhood with relative distances to users' home and intensity of the wind. Instead of designing traditional barometers that show local data directly, the design of *Local Barometers* (Gaver et al., 2008) involved many versions of mappings among wind conditions and the location of neighbourhood where the online news came from. The making of *Local Barometers* includes trial of various sensors, screen displays and mobile devices to detect and illustrate online texts and pictures. Similarly, Gaver et al.,'s *Datacatcher* (2014) was presented as a handheld device with connections between local data and geo locations to make users aware of social conditions of the areas they were in. The design practice of *Datacatcher* began from collecting design innovations (such as GPS system) and experimenting different materials, data, sensors and designs of the handheld device. For *The Curious Home* (edited by Beaver et al., 2007) and *Datacatcher* (Gaver et al., 2014), the practices drawn upon *Research through Design* approach involve design ideation and prototyping carried out in the design studio, and field study including ethnographic study with target users and/or environment. The practical guidances of *Research through Design* in

various contexts were further summarized in Koskinen et al. (2011)'s publication about *Research through Design* from the lab, the field and the showroom.

Another tradition drawn upon *Research through Design* approach is *Critical Design*, which *"uses speculative design proposals to challenge preconceptions, to raise questions and to provoke debate* (Raby, 2007, p.94)". 'Critical' in *Critical Design* is *"more of an attitude than a style or movement; a position rather than a method"* (Dunne & Raby, 2013, p34) towards design practices that followed existing state of affairs (which Dunne and Raby (2013) defined as *Affirmative Design*). Comparing to Affirmative Design that carries out practices with the design norm, *Critical Design* carries out practices to criticise the design norm by adding additional values (Bardzell & Bardzell, 2013). The design artefacts aim to increase users' awareness of existing/future problems and/or to provoke discussions or debates around the problems. Dunne & Raby made a number of design artefacts in a genre of *Design Noir* (Dunne & Raby, 2001), an attitude to make designs to provoke unusual, sometimes ironic experiences which may lead to further design thinking about everyday objects. For example, the *Placebo Project* (Dunne & Raby, 2001) involves making of eight furniture pieces to increase our awareness of the effects from electromagnetic fields in our everyday life, which was usually not noticed. Among the eight objects in the *Placebo Project* (Dunne & Raby, 2001), the *Nipple chair* enabled users' physical sensation toward the electromagnetic field by sensing the vibrations from the nodules embedded at the back of the chair. While vibration at the back of the chair was against users' usual experiences when sitting on a chair, the vibration enabled users to sense the electromagnetic field beyond their vision. *While Dunne & Raby's* practices of *Critical Design* are more into bringing confrontational experiences to the design norm, Bardzell & Bardzell (2013) expanded the concept of *Critical* in *Critical Design* based on critical theories and metacriticism. According to Bardzell and Bardzell (2013), the critical attitude in *Critical Design* does not necessarily mean confronting the status quo. The critical attitude can be unveiling social, political, or simply design problems in the status quo. Taking *The Prayer Companion* (Gaver, 2010) as an example, the device of *the Prayer Companion* (Gaver, 2010) enabled connections between the nuns' spiritual practices and local events broadcasted by news and media comparing to the usual prayers (e.g. regular prayers following the Bible). *The Prayer Companion* is not considered as *Critical Design* in the notion of Dunne & Raby's (2013) definition as the device was not created to provoke unusual experiences (comparing to the vibration of *The Nipple Chair*) during the prayer or the nun's critical thinking of other prayer companions they have used. While Bardzell & Barzell (2013)

regarded *The Prayer Companion* as an example of *Critical Design* which *"strongly criticizes the subordination of materiality to functionality" and "HCI's failures to account intimately for human experience"*(p3305). While my research would explore novel combinations of somaesthetic design, biophysical sensor technology and body-centered practices in everyday settings, my design practices will not be *Critical Designs* because the attitude I take for my research is not 'Critical'. The design artefacts of this research will neither be presented as *Critical Design* in the notion of Dunne & Raby (2013) (which are not aiming to bring unusual user experiences to provoke critical thinking of existing products, design concepts and so on like *the Placebo Project* (Dunne& Raby, 2001)*)*. Rather, my design practices will take an attitude of 'exploratory' and 'unfolding'. Although the design space of this research expanded based on the criticism of Affective Computing and Mindfulness Practice, my design artefacts of this research will not be presented as 'Critical theories' or contributing to a 'critical' attitude to my design practice. My design practices are majorly based on design questions like 'what if I combine design inspirations from various fields to unfold new possibilities' instead of 'how can this (existing design artefact or product) be created or used in another way'.

To clarify how design produces new knowledge in *Research through Design*, Koskinen et al. (2011) proposed their concept of *Constructive Design Research*, where *"construction — be it product, system, space, or media — takes center place and becomes the key means in constructing knowledge.*(p5)*"* In *Constructive Design Research*, the design processes were compared to constructive processes. The design artefacts, concepts, inspirations and outcomes were seen as the building blocks of new knowledge. For example, the design artefacts and user study outcomes of *Drift Table* (Gaver et al., 2004), *Local Barometers* (Gaver et al., 2008) and *Sonic Cradle* (Vidyarthi et al., 2012) produced constructive elements such as using technology to enhance ludic experiences and applying media immersion concepts for meditation as the 'new knowledge' to their research area. Koskinen et al. (2011) proposed practical guidance of conducting *Research through Design* in three contexts—*the lab* (the traditional experimental design research like science research), *the field* (with the target users) and *the showroom* (e.g. exhibitions). The *lab* practice combines experimental evaluation processes, which enable studying in a controlled environment that reduces the variables affecting user experiences (Koskinen et al., 2011) so that designers could explore one or few design combinations at a time. For example, in designing *Drift Table* (Gaver et al., 2004), the designers tried using a variety of sensors and home objects in the lab to explore potential ludic experiences (e.g. curiousity). The co-design sessions of *Sonic Cradle* (Vidyarthi et al., 2012)

were also situated in *the lab* to enable users' full immersion into the mediated chamber and to deploy further design iterations based on individual feedbacks. *The field* situates the design practice into target users and environments or encourage user participation during the design and evaluation process (e.g. *Participatory Design* (edited by Schuler and Namioka, 1993)). For example, to investigate how users would interact with the *Drift Table* (Gaver et al., 2004) with their curiosity, the designers left the table in participant's home with observations over the experiment period. *Drift Table*'s study in *the field* provide constructive knowledge to designing for ludic experience evidenced in the target situation that *Drift Table* was created for. *The showroom* refers to design practices that produce novel designs to provoke critical discussions of current design theories, practices and/or problems (Koskinen et al., 2011). Dunne and Raby's *Critical Design (2013)* is an example design program of *Research through Design* in *the showroom*. *The Placebo Project* (Dunne & Raby, 2001) is an example of Dunne & Raby's *Critical Design* in *the showroom*, involving creating design artefacts that provoke novel sensations towards electromagnetic fields by interacting with everyday objects (e.g. chairs, tables, etc.). The artefacts of *the Placebo Project* were exhibited to the users to provoke new sensational experiences, new ideas and new connections beyond our common experiences with chairs, tables and so on. Regarding the context of my research as exploring applying data visualisation and sonification in designing for somaesthetic experiences, my design practices could be inspired by the lab practice in testing various biophysical technologies and combinations of visualization and sonification mechanisms, yet the evaluation will not follow the experimental process from psychology, engineering or social sciences (e.g. using control groups). My design practices may adapt the field practices that involve users at both design and evaluation stage. As my research is neither taking the *design noir* attitude nor aiming to provoke critical discussions of what is lack in current HCI design, my practices will not be considered as examples of *Critical Design*.

Research through Design has also been applied in designing commercial products. Zimmerman & Forlizzi (2014) described that *Research through Design* was to "make the right thing: a product that transforms the world from its current state to a preferred state" (p176) in commercial product design. The contributions of *Research through Design* in making commercial products could be 1) reframe the design goals and situations with the reflective practices drew upon *Research through Design*, and 2) investigate the speculative future as the world shall become in shaping current design purposes (Zimmerman & Forlizzi, 2014). Comparing to Dunne and Raby's *Critical Design* practices (which are not necessarily

‘make better things’, for example, *the Placebo Project* produced a number of objects that caused unusual, sometimes uncomfortable experiences), Zimmerman & Forlizzi’s (2014) context of *Research through Design* are more focused on making commecial products that work and make our life better. The design artefacts described in Zimmerman & Forlizzi’s (2014) paper were made to solve particular problems, to improve or to extend the kind of user experiences we may obtain from the design artefact. For example, in making the *Reverse Alarm Clock* (Ozenc et al., 2007), the designers focused on making the clock ‘work better’ in the parenting situation by reframing the psychological facts of the particular situations, and selecting the functions and technologies to be integrated. While my design practices may involve reframing of design context, background theories, concepts and methods (as Zimmerman & Forlizzi (2014) stated as one of the contributions of *Research through Design*), the design artefacts I will make are not necessarily ‘the right things’, in my research context, some better functioning applications to enhance somaesthetic experiences. Rather, I consider my design artefacts as alternative examples contributing to HCI design for Somaesthetic experiences. The design practices will provide novel combinations of technology and use situations, or novel user experiences (e.g. mediated body-centred practices in everyday walking or sixth-sense experiences) occurred, while not necessarily optimised combinations or user experiences.

While Koskinen et al. (2011) focused on knowledge construction process of *Research through Design* via *the lab, the field and the showroom*, Redström (2017) noted that *Research through Design* can also make theory. Redström (2017) proposed that theory may not be stable and constant, but may transit, flow and unfold. The articulation of unfolded theory will not only be from evaluation of the design process and user experience, but also be from the presence of the design artefacts (as Redström (2017) put it: *“ a“product” can be a “definition” as influential as anything that comes out of a research process”*(p120)). For example, the Siri defines what a personal assistant on smart phone is, apart from the contributions made through the design thinking and design process of making the Siri or the novel user experience Siri has enabled. The theory made and articulated in one design practice may also contribute to future design practices with unfolded theoretical background (in this research, a design space), and future design practices could also be regarded as a ‘fact’ of the unfolded theoretical background to derive new theories (see Fig. 3.2).

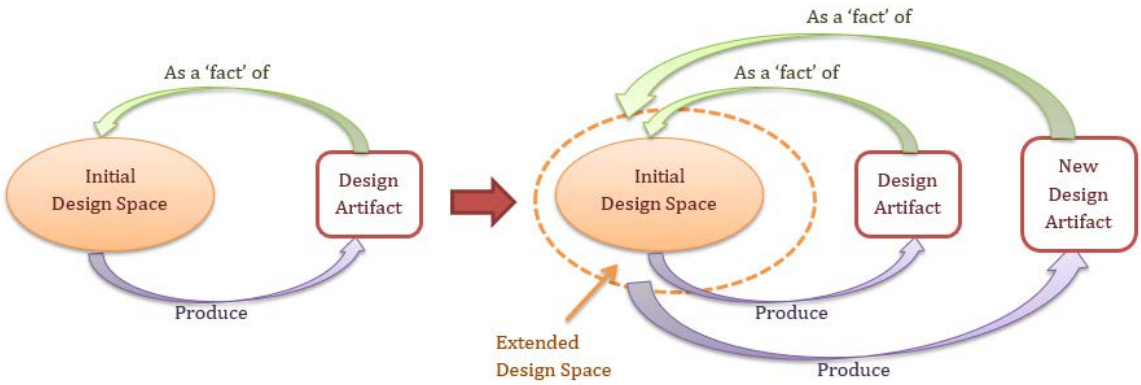

Fig 3.2 Redström (2017)'s 'bucket' model in making design theory: design artefact as a 'fact' to present the theory 'made' by design practices.

By consideration of the exploratory nature of design practice, this research will adapt *Research through Design* as its main approach. Drawing inspirations from cognitive science (affective self-awareness and actuation) and digital art as products from creative practice (audio-visual interaction design), an extendable design space with dimensions of 'somaesthetic experience' and 'cross-modal interaction design' is specified for this research. Section 3.3 introduces the *Provotypes* (Boer & Donovan 2012) as a method in making design artefacts, a specific type of prototype to engage users in exploring potential affective experience been provoked. Section 3.4 describes the qualitative approach to be used in this research to provide open evaluation of users' affective experiences over a continuous period of time. Section 3.5 will discuss *Annotated Portfolio* (Bowers 2012) as the method to articulate conceptual contributions of this research (i.e. the 'new knowledge' discovered by *Research through Design* practices), with a comparison among existing conceptual articulation methods (e.g. strong concepts) to illustrate the relevance of using *Annotated Portfolio* in this research. Section 3.6 will state the ethical concerns and approval obtained for this research.

3.3 Making 'Provotypes': Prototyping to Provoke Personal Experience

In HCI design, gathering user requirements is the first step of the design cycle. Common methods for requirement gathering include *Cultural Probe, Technology Probe and Questionnaire Survey.* These methods differ in how they are conducted yet they all collect user's preference, opinions and actions towards a design problem. Prototypes are usually created based on these requirements and designers' intentions, yet there may be unfulfilled requirements, conflicting requirements among designers and users and/or undiscovered design

possibilities. In studying somaesthetic experiences with digital art and technology, it is difficult to imagine how relevant design concepts come together to foster bodily experience without a tangible artefact to present the combination and the role of each area (e.g. mindfulness practices, somaesthetic design and data visualisation/sonification). In *Research through Design*, it not only involves constructing theoretical framework with relevant concepts in related fields, but also involves making artefacts to provide a tangible medium in delivering the new knowledge. In designing for affective experience, it is crucial to not only understand users' experience after created an artifact with designers' interpretation, but also take provoked user experience into the early stage of design process. The artefacts created for provoking user experiences are regarded as Provotypes (Boer & Donovan 2012).

Provotypes, according to Boer and Donovan (2012), are prototypes created with a purpose of exploring provoked user experience throughout their use of the prototype thus to inform the designers about potential features, conflicts and design possibilities in the future design. In HCI design for business, designers create *provotypes* to find out what experiences users may encounter that helps them decide what they need to do in the future design, or magnify the unrealistic facts and conflicts in the proposed design requirements from the team. In this research, *provotypes* are created to explore the design possibilities of combining digital art and technology by provoking potential somaesthetic experiences, which may be constrained from the designer's perspective. These *provotypes* could provide first-hand information on the changes expected by the users, articulate the space of design possibilities and guide future design directions in planning for design improvements.

3.4 Qualitative Approach for Open Evaluation

In the context of this research, somaesthetic experiences are highly related on their contexts such as sensations and cognitions inside the body, interactions from the environment and the mood of the person. People from different backgrounds or experienced different events may feel differently while practicing the same activity. Quantitative methods in *Affective Computing* estimates affective states based on a person's body movements and biophysical signals represented by quantitative data, yet it may not be able to understand the actual sensations, feelings and thoughts of the person. Quantitative methods in biophysical sensing and analysis can illustrate strength and arousal of bodily experiences, but rarely could

understand the nuance and the context behind the arousal. As affection is a subjective personal experience, it differs for each individual under each context. As noted in Höök's concept of designing for *Affective Loop,* affective experiences shall be seen individually while we design to achieve an 'equilibrium' of affective experiences (Höök 2008). A qualitative approach is therefore more relevant in understanding individual differences throughout the study of user experiences.

As somaesthetic experience not only differs among different individuals but also varies among time, individual cases as grounded evidences to the research, but rather, individual cases shall be taken as 'a fact that is only true to this person at this period of time'. Somaesthetic experiences involve both momentary experiences (e.g. muscle pains during walking and running) and continuous and dynamic processes over various time periods. This requires a research methodology that takes an empirical approach, accepts open discussions of uncertainties, and grounds findings within their contexts instead of general case in its evaluation process. In this research, I not only conducted short-term user evaluation for immediate and short-term affective experiences (e.g. how did users feel at the beginning of the practice or within a short time of the practice), but also conducted empirical user studies to evaluate users' encountered somaesthetic experiences in a continuous time. Section 3.3.1 will describe the data collection and qualitative analysis being used in the two case studies of this research: 'Ambient Walk' and 'Hearing the Hidden'.

3.4.1 Data Collection and Qualitative Analysis

For Experience-centred Design, it is crucial to take feedback on participants' experiences over a period time. Each individual will explore the design artefacts under their individual contexts—for example, their own choice of walking route, their mood before the study and their expectation about how they shall use the artefacts. Due to the individual differences of somaesthetic experiences, this research involved an in-depth review of individual cases instead of in-breadth review of group behaviours or experiences. Therefore, I recruited a small group of participants to volunteer in my user evaluations. Each participant spent time with the apps I made for a period of time (varied from 1 hour to 1 week depending on the design context). The data collection in this research included recordings of user activities while using the app, online questionnaire, user diaries and face-to-face interviews. The

audio/video recordings were kept for reference of user comments on their experiences and evidences of user actions. The user diaries were collected to articulate users' somaesthetic experiences mentioned in their interviews. All data were collected with user permission and awareness of the purpose. Each participant was consulted for their permission of using their pseudonyms/recordings/transcripts in further publications. All participants were anonymised in the description of user data and research findings by being assigned pseudonyms.

The data analysis for this research follows a qualitative approach that studies individual cases based on individual contexts. It uses thematic analysis (Braun & Clarke 2012a) as the main method to analyse user feedbacks based on the main aspects to be investigated in this research. The themes include the somaesthetic experiences users engaged (including mindfulness experiences and other new bodily experiences may be found), the level of attention users pertained, the intention and perception of their practices with the prototypes under different scenarios. The findings would explain individual user feedbacks based on the themes identified, with consideration of individual contexts.

3.5 Annotated Portfolio as Conceptual Contribution

In *Research through Design*, the making of design artefacts reveals how a new concept was formed, apart from the artefacts themselves representing the new concept. According to Frayling (1997), the new knowledge generated by *Research through Design* is embodied in the design artefacts. The goal of constructing new knowledges is not to make them *"communicable in (the sense of) verbal communication, but in (the sense of) imagistic communication"* (Frayling, 1997, 'emphasis in the original'). Therefore, it is important to annotate the process of how the new concept was unveiled, developed and implied during the innovation, design and making of the artefact. *Annotated portfolio* is a new and increasingly used reflective method in design research that summarizes potential insights from design practice and respects the multi-modality, multi-disciplinary and multi-dimensionality of making within a design space (Bowers 2012). Gaver and Bowers (2012) suggested the use of *Annotated Portfolio* as a retrospective approach to reflect the findings from making with concerns of the functionalities, values, aesthetic qualities, productivity, reasons for creation and target users of the artefact and plotting them into a common design space made clear by annotations. The annotations of design artefacts presented in *Annotated Portfolio* will not only be the findings from individual design practices per se, but also shared values,

connections and findings addressing broader concerns derived from the collection of design practices (Bowers, 2012). An example of *Annotated Portfolio* is *The Curious Home* (edited by Beaver et al.,2007), which documents a collection of design practices situated in the home and community environment aiming to cultivate ludic experience. Each design practice of the Curious Home involved different conceptual inspirations and technology innovations (e.g. The *Local Barometer* (Gaver, 2008) used GPS, online news fetching and wind sensor. The *Drift Table* (Gaver et al., 2004) embedded aerial photography and pressure sensing technology), while the annotated design practices unveiled the common ground of 'designing for ludic experience at home and/or community level', including common practices, user experiences (e.g. users were curious about what users have seen or felt through the design artefacts), evaluation methods (e.g. ethnographic studies involving installing and evaluating user experience at users' homes), etc.

Another way of presenting conceptual contributions of practices draw upon *Research through Design* is *Strong Concept* (Höök & Löwgren, 2012). The *Strong Concept* was proposed to articulate 'middle territory intermediate-level knowledge'(p1) generated by design research that was more abstract than findings from particular practices, while less general than theories. Practically, *Strong Concepts* are annotated and abstracted from a collection of design practices. The abstracted *Strong Concepts* would have the potential to describe a class of design applications, use scenarios or genre of designs, and to generate new design practices within the class the particular *Strong Concept* describes (Höök & Löwgren, 2012). An example *Strong Concept* is *Somaesthetic Appreciation Design* (Höök, 2016). *Somaesthetic Appreciation Design* (Höök, 2016) is abstracted from a number of similar design practices, for example, the *Soma Mat*, *Breathing Light*, and *Sonic Cradle*. *Somaesthetic Appreciation Design* (Höök & Löwgren, 2012) was proposed as a *Strong Concept* to describe the common design background, framework, principles, collection of methods, and/or the genre of HCI design for somaesthetic experiences. The concepts, practical methods and guidance in *Somaesthetic Appreciation Design* directly informed future design practices in the same genre. This research will use *Annotated Portfolio* as not only a final outcome that summarizes the findings within the design space and hence to give structure to the dissertation, but also intertwine this approach in the progress of design as a formative approach. The *Annotated Portfolio* of this research will derive findings from individual design practices and connections/abstracted knowledge among the design practices. The findings of the design

practices may not be adequate to form *Strong Concepts* as the purpose of my design practices are to provide alternative examples within the umbrella of *Somaesthetic Design*.

3.6 Ethical Concerns

This research involved case studies about affective experiences of human participants. Therefore, an ethical approval was obtained before starting studying on human participants. This research has obtained a general ethical approval following the Code of Good Practice in Research (Newcastle University 2011) and the procedure listed on Newcastle University Research Ethics page. The ethical approval form is attached in Appendix B1.

This research did not require an ethical approval by the National Research Ethics Service (NRES) as it is not working within NRES listed areas (see 'Ethical Considerations of Research' (National Research Ethics Service (NRES) 2017)). This research recruited participants from adults (aged 18+) which does not involve children or vulnerable groups. All participants were recruited as volunteers with full consent and information of the study provided. Each participant was provided with an information sheet and a consent form (either online or paper form). They could decide to participate after fully understood the purpose, the instruction and potential risks of the study. The study involved discussion of affective bodily experiences mainly related to emotions, physical sensations and intention of movements of their body, which did not involve sensitive topics such as sexual activity and drug use. All participants' names were pseudonymised in reporting on the research and findings.

Chapter 4: 'Ambient Walk': Engage Somaesthetic Experiences in Walking Meditation

In this chapter I introduce the first research project, 'Ambient Walk', which explored the use of sonification of body movements to enhance bodily experiences through Mindfulness practice. 'Ambient walk' is a mobile application (app) that generates user-performed sonic feedback to engage users in somaesthetic experience through daily walking activities. It was a design-led exploration of data sonification to engage users in somaesthetic experience through an increased awareness of their body activities. In this chapter, I describe: the initial conceptual design that took inspiration from walking meditation and HCI design practices for body-centred practices; the autobiographical explorations with various biophysical sensors, visualization and sonification mechanisms; the observation at the BritishHCI Interactions Gallery[3] (Rowland et al. 2015), the design iteration to enhance bodily experience; and an empirical user study that unveiled various ways of engaging somaesthetic experiences. The whole design exploration adapts a *Research through Design (RtD)* approach aiming to generate new knowledge from design practice. The discussion drawn upon the empirical study of 'Ambient Walk' explicates how my design practice began: creating an application that combines data visualisation, sonification and biofeedback applications to foster mindfulness experiences, while unfolding new bodily experiences other than Mindfulness that led to re-accent my research explorations in adding sixth-sense experiences, extensions of initial design space, or simply inspirations of designing for new experiences. The user study of 'Ambient Walk', as presented herein, also opens up a discussion about how people may see real-world interaction, as a distraction or a complementation to the immersive experience, which may inform a new design concern for future HCI explorations.

4.1 Walking Meditation as Body-Centred Practice

From an ethnographic point of view, Ingold (2004) takes walking as a rhythmic practice in which one could feel the rhythm by following the rise and fall of the feet. With focused attention on this rhythm, people can more fully understand their bodily movements,

[3] BritishHCI Interactions Gallery is a pop-up gallery of creative art and design works within the HCI field at the BritishHCI conference in Lincoln, UK in 2015.

sensations and perceptions of their walking and breathing, and possibly enjoy immersing themselves in such an experience. However, such rhythm in walking is not focused on in current mindfulness practices and HCI design for affective interventions. Walking meditation, according to Thich Nhat Hanh, cultivates a strong awareness of the sensation of bodily movements while walking (Hanh 2006). The practice encourages practitioners to focus on bodily sensations during every movement of walking. While practicing walking meditation, the practitioner's attention is gradually brought to the sensation of lifting each foot, the airflow in the body via breathing, the mundane environmental noises from traffic and the voices of other pedestrians. S/he starts to immerse in a new, ambient and meaningful moment.

Fig 4.1.1 A Buddhist monk is practicing walking meditation (Image from https://mettarefuge.wordpress.com/2010/03/10/freshen-up-your-practice-with-walking-meditation/)

The practice of walking meditation brings an inward focus to the experience of the body, both sensational and perceptual. Practitioners maintain a high level of attention to the feelings and movements of their bodies to achieve such body awareness – for example, to understand how fast their breathing are and how the body feels. Thich Nhat Hanh (1996) provided an example walking meditation focusing on breathing towards steps by counting numbers or using words:

"If the rhythm of our breathing is 3 (inhale)-3 (exhale), for example, we can say, silently, "Lotus flower blooms. Lotus flower blooms"..." (p26)

The attention and awareness of the 'here and now' not only include practitioners' perceptual experiences of their body, but also the surroundings where their body were in:

"As you walk, be fully aware of your foot, the ground, and the connection between them, which is your conscious breathing." (Nhat Hanh, 1996, p58)

The awareness of surroundings en route of the Walking Meditation was distinct from some other body-centered practices (such as the Body Scan). The Body Scan in Kabat-Zinn's MBSR brings an 'inside-out' experience which practitioners focus on the physical sensations (such as muscle pain and tiredness) of different body parts. While Walking Meditation brings both 'inside-out' and 'outside-in' experiences of the body which practitioners are also aware of their body being reflected by the surroundings (e.g. feeling 'alive' when practitioners look around to see the sceneries and passengers around them).

Many HCI and creative art practices have explored this using interactive technology, audio and visual art to enhance people's perceptions of their bodies in various contexts. Some explored body activities with machine drawing and soundscape (e.g. *Metaphone* (Simbelis et al., 2007)) some were applied in performances (e.g. *Mind Pool* (Long and Vines, 2013), *Eunoia II* (Park, 2014), *exhale* (Schiphorst, 2005)) to express the connections between body activities and physical movements from objects (e.g. the water movements of *Mind Pool* and *Eunoia II*, the fabric vibrations of *exhale*, etc.). Some explored creating interactive and portable devices to help practitioners engage with body-centered practices (e.g. *Spheres of Wellbeing* (Thieme et al., 2013), *MindfulHU* (Zhu et al., 2017), *Soma Mat* and *Breathing Light* (Ståhl et al., 2016)). However, few HCI designs have explored the context of Walking Meditation as a body-centred practice derived from an everyday activity (i.e. walking) that also engenders reflective experiences towards bodily interactions with the surroundings. The surroundings of Walking Meditation may not have a physical boundary, like the dark chamber in *Sonic Cradle (Vidyarthi et al., 201)* or the lamp for *Breathing Light* (Ståhl et al., 2016). While Thich Nhat Hanh introduced using gatha poems to reinforce the awareness of body in breathing and walking in Walking Meditation, I would like to explore whether using generative visualisation and sonification would reinforce user attention, observation and awareness of their body, thus to foster aesthetic perceptions of their body in walking.

In this project, I explored a design with biophysical sensing technology and audiovisual interfaces to cultivate body awareness in walking meditation, which could be practised

anywhere and anytime while walking. For the initial exploration, I proposed the design of 'Ambient Walk', an application that fosters somaesthetic experiences during everyday walking. (Chen et al. 2015). It involves the design concept, user scenario, technology to be used, sonification and visualisation design. By understanding breathing, walking pace and purpose-generated sound sequences, users become more aware of their bodily movements, fostering perceptions and feelings of the body. Sections 4.2 and 4.3 will outline the design of 'Ambient Walk', including the user scenarios, explorations of different sensors and visualisation/sonification design, the initial design and technical specification of the prototype mobile phone application, and the data sonification and visualisation techniques. In Section 4.4 I will discuss the initial findings from a user observation at the Interactions Gallery, which was conducted as a first approach to explore potential affective experiences encountered and suggested improvements in the design iteration. Sections 4.5 will describe the design iteration of 'Ambient Walk' based on the user feedback at the Interactions Gallery (Rowland et al., 2015), including collaboration with sound artists at Culture Lab to make different versions of sonifications. Section 4.6 will discuss the findings from the week-long user study with five participants from different backgrounds – a mindfulness professional, an HCI designer and laypeople. The discussion is based on a thematic analysis (Braun & Clarke, 2012), regarding body awareness and attention, affective experiences, perception of thoughts and out-of-body interactions during the practice.

4.2 Using Autobiographical Experience to Help Design 'Ambient Walk'

To understand potential experiences user may engage during walking meditation, it is crucial for the designers to get involved in the actual practice to produce a design source. Autobiographical design is a method to *"provide detailed, nuanced, and experiential understanding of a design space"* (Neustaedter & Sengers 2012, p.28). In designing for 'Ambient Walk', autobiographical practices could be helpful in brainstorming potential somaesthetic experiences users may engage, choosing and combining sensors, and exploring various feedback mechanisms to form an initial design source. Therefore, I performed walking meditation myself, created diaries of my own walking meditation experiences and how they may apply to other users. The autobiographical practices in this research project were not only conducted during the early exploration of the combinations of sensor

technologies, interfaces and audio/visual mapping, but also conducted during the making of 'Ambient Walk' prototype.

4.2.1 Explore Various Biophysical Sensors and Devices

I. Inspirations and Case Studies

Biophysical sensors have been used to detect bodily responses from emotional experiences. Heart rate and Galvanic Skin Response are two common factors being monitored in HCI innovations for bodily experiences. In Vaara et al. (2010)'s design of *Affective Health*, the designers experimented with Galvanic Skin Response (GSR) sensor and heart rate sensors to record emotional arousal and energy level related to stress and anxiety. Khut (2007) used a combination of pulse sensor to measure the heart rates and GSR sensor to monitor skin conductance to joint-illustrate the user's' emotional arousals for his art installation *Cardiomorphologies*. Khut also made the *BrightHeart* (2011) app for art-mediated relaxation training for children with physical pains, stress and anxiety during medical procedures. For *BrightHeart* (Khut et al., 2011), a pulse sensor (connected to arduino) that can be attached to user's fingertip was used to detect real-time heart rate variability. As breathing activities are one of the key practices in mindfulness practices, breathing is also a body activity to be monitored in designing for mindfulness practices. In *Sonic Cradle, Vidyarthi* created a stretching belt for users to wear at their chests to detect breathing. Other than heart rate, skin conductance and breathing, Lisa Park's *Eunoia* and Vines et al.'s *Mind Pool* used commercial EEG sensors to detect brain activities, Donnarumma et al. (2012), used EMG sensor to detect muscle tenses to create biophysical music. Some creative artists embedded the biophysical sensors as part of the art installations. As Khut's *Cardiomorphologies* (2007) aimed to provide immersive experience with his generative artworks created with users' biophysical data, the sensors are embedded in a device linked to the screen. Some creative practices made wearable devices with the chosen biophysical sensors to enable portable live tracking and interacting with users' body activities. For example, *Affective Health* (Vaara et al., 2010) explored a number of wearable biophysical sensors, including heart rate sensor attached to a belt and Galvanic Skin Response sensor to be worn on the wrist so that users could engage with the *Affective Health* app on the go.

Apart from biophysical sensors to detect body activities, other sensing technologies have also been used to detect body movements that affect our bodily experiences. *Affective Health* (Vaara et al., 2010) used motion sensors (e.g. a combination of accelerometers) to capture body movements that may affect detection results of GSR and heart rate sensors. In detecting body movements in walking, Papetti et al. (2010) developed interactive shoes to capture feet pressure data at walking with a number of carefully positioned force sensors. In developing the prototype interactive shoes, Papetti et al. (2010) used low cost force sensors to detect pressures at different parts of the shoes caused by the feet movements while walking. The pressure data were then used to simulate sonic feedbacks towards users' walking gestures. As body movement is an important factor that affect users' somaesthetic experiences in walking, these case studies provided me examples of how to integrate body movement sensors in designing interesting audio/visual interactions to foster users' aesthetic appreciation of body in walking. As walking activities involve lots of body movements, it is beneficial to make the sensory device (to detect real-time biophysical/motion data) mobile. According to Papetti et al. (2010), *"...all physical components need to be tailored in order to minimize size, weight and power consumption, meanwhile guaranteeing an acceptable performance of the interface. Moreover they must be robust, since they are moved around by users engaged in walking or running tasks" (p118)* when making mobile sensory devices. To find out suitable combinations of sensors, materials and audio/visual feedback hardwares, it is important to explore a variety of sensors, devices, materials to connect the sensors and/or make them wearable, visualisation and sonification hardwares in making 'Ambient Walk'.

Fig 4.2.1.2 Papetti et al. (2010)'s interactive shoes prototype, with force sensors and low volume speakers attached to the shoes to detect and sonify walking movements in real time.

II. Experiment with Sensors and Devices

To gain a better understanding of the features and best integrations of biophysical sensors, I gathered and explored different types of biophysical sensors available from Culture Lab where I was working, and commercial products. Based on the inspiration from the case studies stated in part I, all biophysical sensors I chose to test could be integrated into wearable devices or portable for everyday use. Heart rate, Galvanic Skin Response and breathing were three most common biophysical feedbacks to be captured in previous HCI designs for enhanced bodily experiences. Therefore, the biophysical sensors I selected in my experiments are specifically functioning in recognising heart rates, skin conductance and breathing. While art installations with responsive physical objects (e.g. *Breathing Light* and *Pulse Room*) or on-screen visualisation (e.g. *Cardiomorphologies*) would also bring immersive experiences reflecting users' body activities, art installations have more constraints on their settings and space boundaries so that users may not able to gain similar body experiences elsewhere. Comparing Khut's *Cardiomorphologies* (2007) and *BrightHeart* app (2011), the former settings apart from the sensors requires a large screen to be installed inside the exhibition room while the latter requires an iPhone or iPad. Users needed to stay in front of the screen, put on the sensors and look at the interactive artwork on the screen for *Cardiomorphologies (Khut, 2007).* For the *BrightHeart* app (Khut, 2011), users can enjoy interacting with the artwork on the mobile phone or iPad with the heart rate sensor on hand and carry the devices around while sitting at home or walking. To allow users reflect their body activities with 'something in hand' while walking, 'Ambient Walk' was envisioned as a mobile application rather than an physical art installation, and had on-screen visualisation and interaction.

The list of sensors I will explore were mainly chosen from the biophysical sensors available at Culture Lab. The hardware included the e-Health kit and Pulse Sensor for Arduino (accessed in 2014)[cite Arduino website], an open-source platform with a wide collection of hardwares such as electrical boards, sensors, LED lights etc. that enable easy programming and fast prototyping of hardware-based interactions. With inspirations from Lu et al. (2012)'s prototype of stress detection with smartphone microphone, I also tested an embedded microphone on an Android phone to compare the accuracy of breathing recognition and simplicity of user interaction with the sensors. For e-Health kit and Pulse Sensor Arduino, I

needed to connect the e-Health Arduino shield or the sensor module to an arduino board (here I used Arduino Uno to start) with data transmitting modules (here I used an HC-06 Bluetooth Module) to send data to the 'Ambient Walk' app. In the sensor experiment stage, I focused on testing the usability of each sensor, how easy is it to use them together with the mobile phone and how each sensor affected my somaesthetic experience while practicing walking meditation. At this stage I created a simple mobile phone interface to plot the data received from the embedded microphone or the Arduino sensors. My experiment with each sensor took 5-10 minutes to get first-hand user experiences regarding accuracy and latency of biophysical data detection, interaction mechanism, intrusiveness to users and the feasibility of integrating each sensor in 'Ambient Walk'.

The breathing sensor in the e-Health Kit is the Airflow sensor that detects air flow changes during users' breathing activities. To use the Airflow sensor, I followed the instructions to attach the sensor module to my nose and put the wires behind my ears to secure the sensor module to the nostrils. After enabling data transmission between the sensor and the phone, I began my walking meditation with the Arduino board with e-Health shield in one hand and the mobile phone in the other hand. I inhaled and exhaled for three steps each and checked data on the phone screen every six steps. The data shown on the screen indicated each exhalation as the airflow was significantly different. However, I found it uncomfortable to wear the airflow sensor after a few steps. The Airflow sensor near my nose distracted me from focusing on my breathing and walking as most of the time I kept wondering "whether it looks weird to wear this" or "whether the sensor is falling off because the strings were loose". When I began testing the e-Health Galvanic Skin Response (GSR) sensor, I felt the sensor was easier to wear as it only requires attaching three pads to my surface skin. While I walked with the GSR sensor attached to my skin for a few minutes, I had less worries of how I appear when I carried the sensor with me or whether the pads would fall off. I was able to obtain fuller attention to my breathing, my steps and the ground my feet touched. After 1 or 2 minutes of walking meditation with the e-Health GSR sensor, I noticed subtle pain on my skin at where the sensor pads were attached alongside the muscle tense on my legs and the fullness/emptiness on my abdomen. When I checked the data recorded on the phone after practicing walking meditation for 5 minutes, I noted that the fluctuation of skin conductance were hardly noticeable. After completed testing with e-Health sensors, I found both of them could take my attention to 'whether the sensors were at the right place' instead of my breathing and walking. I could hardly ignore the minor pressures of the sensor unit near my

nose/attached to my skin and the strings on my ears. At the same time my thoughts of how did I appear like with the sensor on my face distracted me from observing and accepting what happened during my walking meditation.

Upon completing my tests with the e-Health sensor kit, I tested wearing pulse sensor Arduino to track heart rate variability during walking meditation. I attached the infrared unit onto a glove to hold the pulse sensor at the fingertip for best tracking result. To make the sensor more wearable, I used an Arduino Lilypad which has the same ATMega328P unit as the Arduino Uno but better sized and assembled for wearable projects. I began my walking meditation with the same rhythm (3-steps inhale and 3-steps exhale). The pulse sensor itself was less distracting comparing to the e-Health sensors as it was stable at my fingertip. I was able to fully focus on how my body feels when I breath and when my feet touched the ground, instead of wondering whether I wore the sensors in right ways. The LED light blinked to my heart beats to reflect how active my body was. I deliberately took longer inhalation, exhalation and gaps between two steps to see whether the blinking rate of the LED would change. After a few rounds of slower walk, I hardly noticed any change of the blinking frequency of the LED light even I felt a significant relaxation of my body. However, the data shown on the phone screen indicated the changes of heart rates which synchronized with the period I performed slow walking meditation.

Fig 4.2.1.3 Experiment with Pulse Sensor Arduino for Heart Rate detection.

While Lu et al. (2012) provided an example of using mobile phone microphone to detect emotional cues in human voices and speech, there were few evidences about user experiences with the synchronisation between microphone detection and users' breathing activities comparing to other biophysical sensors. The advantage of using smart phone microphone to detect breathing was it would be easier to integrate the code for breathing/walking detection with the code for data visualisation and sonification. The latency of data transmission could

be minimized as the breathing and walking data would be captured from the same device (although different modules) instead of wireless transmission via Bluetooth. With my initial test of mobile phone microphone to detect breathing behaviour, I used a voice recording app already available on my Android phone to see the patterns of breathing sound. I performed breathing like how I did in my walking meditation while holding the microphone towards my face, which was inhalation for three steps and exhalation for 3 steps. The sound signal shown on the recording app clearly mapped with my breathing behaviour. One major challenge of using microphone to detect breathing is the analysis of sound sample may result in high latency of breathing intensity detection due to a potential large size of sound sample array. With the concern of synchronisation between breathing sound detection and my actual breathing behaviour, I wrote a demo app (for Android phone I have for testing all devices) to capture and analyse breathing sound in real time. The demo app detects the peaks of filtered sound signals then logs the intensity of peaks and times between two peaks to capture breathing periods. To avoid detection of non-peak signal caused by noise, I applied a de-bouncing period of 1 second. To see how fast the breathing detection was, I wrote lines to show a dynamic circle to show the intensity of breathing sound and a text box on the screen to show the breathing period data. With the demo app, I held the phone with its microphone towards my nose and mouth to test breathing sound detection. Then I began my walking meditation with 3-step inhalation and 3-step exhalation like that I practiced before with the sound recording app. The circle on the phone screen increased and decreased accordingly towards my inhalation and exhalation immediately. I held the phone microphone close to my mouth and began my walking. Although holding my phone in hand at a certain position can be exhaustive over time, I found I was more able to focus on how my body feels during the breathing and walking rather than thinking of anything else, for example, how I look like with the airflow sensor on my head or the pulse sensor on my hand, The size of the circle changed according to the volume of inhalation/exhalation rather than the airflow of breathing, for which a number of breath visualisation mechanisms will be explored and described in Section 4.2.2. Comparing to my experience with e-Health sensors (Airflow and GSR), Pulse Sensor Arduino and mobile phone microphone, I found out that using mobile phone microphone for breathing detection was the least intrusive way for me to engage with visualised and sonified walking meditation. While other sensors request data transmission to the phone for the visualisation/sonification, using the microphone on the phone allowed faster data transmission and easier integration. During my experiments, the data transmissions via Bluetooth for e-Health sensors and Pulse Sensor Arduino took longer time than the processing time of

breathing sound samples. (Detailed comparison of different sensors can be referred to Table 4.2.1 below.) However, holding mobile phone microphone to users' mouth is not the most user-friendly interaction. For this reason, I also tested a number of headphones with in-line microphones to see whether it would be more user-friendly if we were able to hold the microphone closer to the users' mouth.

Body Activity	Sensor	Features	Limitations
Breathing	E-health kit (Arduino) Airflow sensor	Accurately detect the exhalation with air perfusion	The data for inhalation was not clear; User need to wear the sensor on their head with the detection unit close to their nose, which may not be hygienic and easy to use;
	Microphone	Easy user interaction: just need to hold the phone/microphone near their face; Fairly accurate detection of breathing sound; User can access via things they have instead of getting extra devices;	Need calibration to determine the threshold of a detected breathing activity; Hold the phone towards users' face may still be distracting;
Heart rate	Pulse sensor arduino	Easy to embed into wearable devices; Detect and show the heart rate in bpm in real time (via the LED light on the pulse sensor); Fairly easy user interaction;	Need to attach the sensor at certain location on the body for high accuracy (e.g. ears, and fingertips); The heart rate data did not illustrate significant difference over time if user did not have high energy level changes (e.g. from relaxed to highly stressed after exercises);
Galvanic Skin Response	E-health kit (Arduino) Galvanic Skin Response Sensor	Skin conductance can be another modality to articulate arousals and energy levels.	The data changes little over the time I practiced walking meditation; The sonification of data with few changes may not encourage active user engagement.

Table 4.2.1 Comparison of my experiences with different biophysical sensor available at Culture Lab and mobile phone microphone.

Upon the choice of using mobile phone microphone to detect breathing, I experimented with various types of microphones available in the Culture Lab and the commercial market. In Lu et al (2012)'s prototype StressSense, the researchers used the embedded microphone on the mobile phone to detect personal stress levels from human voice and speeches. The prototype of StressSense used a Gaussian Model to recognise vocal patterns related to stress from collected audio samples. Later, Avalur and Aiello (2013) explored sound-based breath detection using a microphone. Avalur and Aiello's practice provided an example algorithm to detect breath patterns (e.g. breath period, intensity of inhale/exhale, etc.) from sound

recordings. Apart from embedded microphone on the smartphones, there are also microphones compatible to smartphones available in the commercial market e.g. in-line microphones on the headphones/earbuds. After experimented with various biophysical sensors, I have also tested breath detections with different types of microphones to explore the quality of sound recording and usability. In designing for sound-based interactions, using headphones were usually recommended to enable immersive listening experiences. For example, in *Sonic Cradle* (Vidyarthi et al., 2012), the headphones enabled the participants to be fully immersed in listening to the soundscape generated by their breathing. Different types of headphones may provide different bodily experiences and usability concerns. For example, over-the-ear headphones may provide better immersive listening experiences, more comfortable to wear while comparatively noticeable when carrying them around due to the headphones' size and weight. In-ear headphones could be carried in users' pocket and very lightweight to wear, while users will notice the feelings of the earbuds that may not be comfortable. As sonification will also be a major part of reflective feedbacks to cultivate users' somaesthetic experience, I also tested a number of combinations of headphones with the microphones available in the market at the time of testing. In the first round decision-making experiments with headphones and microphones, I chose in-ear headphones, on-the-ear headphones and lower-budget Bluetooth headsets (under £50) to resemble the average headphone choices of my target users. My experiment with each combination may take from 5 to 10 minutes. The list of combinations of headphones and microphones include the following:

i). Wired headphones+Phone microphone;

ii).Wired headphones+microphone attached to earpiece (e.g. gaming headsets for PC/Mac/smartphones);

iii).Wired headphones+in-line microphone;

iv).Wireless headphones+ Phone microphone;

v). Wireless headphones with microphone;

At this stage I used an android voice recorder to test the sound quality and patterns of users' breathing sound.

After tested with the five different combinations, I found the most user-friendly combinations of devices were headphones with in-line microphones or headsets with microphones attached to the head pieces. However, the sound quality of headphones with in-line microphones were poorer than the phone microphone at the time of testing. This was because the in-line microphones provided loud background noises that interfere with the sound quality of breath

recording. There may be higher-end headphone products with wireless connections or higher quality embedded microphones, yet these products are relatively expensive for the average users. For the first 'Ambient Walk' prototype my purpose was to see how data visualisation and sonification enabled strong, sometimes novel somaesthetic experiences from the users. Therefore, I selected the best device combination available at the time of prototyping with consideration of using better devices in future studies if necessary.

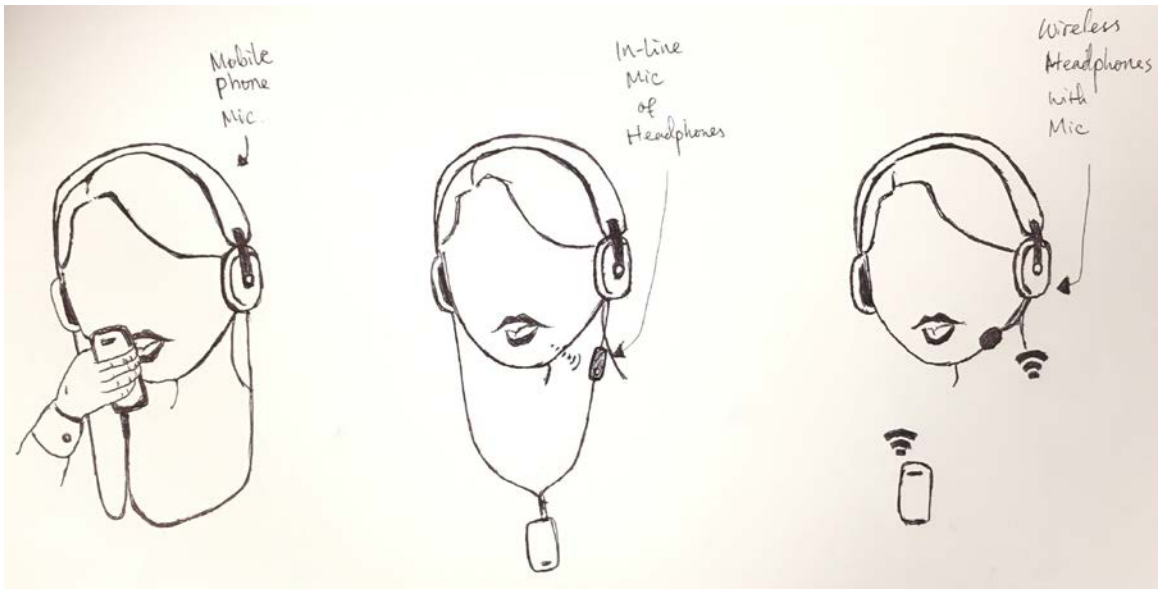

Fig 4.2.1.4 Sketch of user interactions with different combinations of headphones and microphones.

4.2.2 Experiment of Data Visualisation

I. Inspirations and Case Studies

Based on the exploration of biophysical sensors in Section 4.2.1, I chose to use mobile phone to detect users' breathing and walking pace during their walking activities. As walking is an activity requires high level of mobility, physical visualisation from objects is not an ideal mechanism due to its constraint in space. For example, Lozano-Hemmer's *Pulse Room* (2006) requires a large number of light bulbs installed on the ceiling. If 'Ambient Walk' takes the *Pulse Room* (Lozano-Hemmer, 2006)'s visualisation mechanism, the participants would only be able to reflect their walking meditation in the room with the light bulbs installed in. The constraint of space is not an ideal situation for 'Ambient Walk' which aimed to allow users to foster somaesthetic experiences in their walking at anywhere. Previous HCI design for bodily experiences have explored various techniques to illustrate real-time biophysical feedbacks and/or affective qualities. For example, Khut et al.'s *BrightHeart* (2011) app used dynamic circles to represent users' stress or energy levels with various sizes, shapes and colours. Vaara

et al.'s *Affective Health* (2010) used an infinite spiral to represent continuous stress and energy states. The designers of *Affective Health* used different colours to map with the skin conductance and the shapes to illustrate the active levels of body movements and energy levels. The continuous spiral allowed users to trace their emotional states, emotional events and active levels at past and present moments. The visualisation of *BrightHeart* (2011) 'evolves' immediately towards the children's heart rate, which provided a mirror-like experience for the children to focus on their body activities at 'here and now'. Both the *BrightHeart* (Khut et al., 2011) app and *Affective Health* (Vaara et al., 2010) provided more abstract visualisations of bodily experiences fostering open interpretation and imagination of the visual artwork. The multiple visual metaphors (e.g. colours for stress level, shapes for energy level, etc.) of *BrightHeart* (Khut et al., 2011) and *Affective Health* (Vaara et al., 2010) increased users' attention to the visualisation itself. While for 'Ambient Walk', the visualisation would be created for users to reflect their body activities quickly and not fully immersed in looking at the visualisation. This is because 'Ambient Walk' aims to foster users' attention to the feelings of their body in breathing and walking rather than looking at the screen. In my exploration of visualisation techniques for 'Ambient Walk', I explored a number of simple shapes and animations that represents the dynamics of breathing and walking without creating complex visual metaphors.

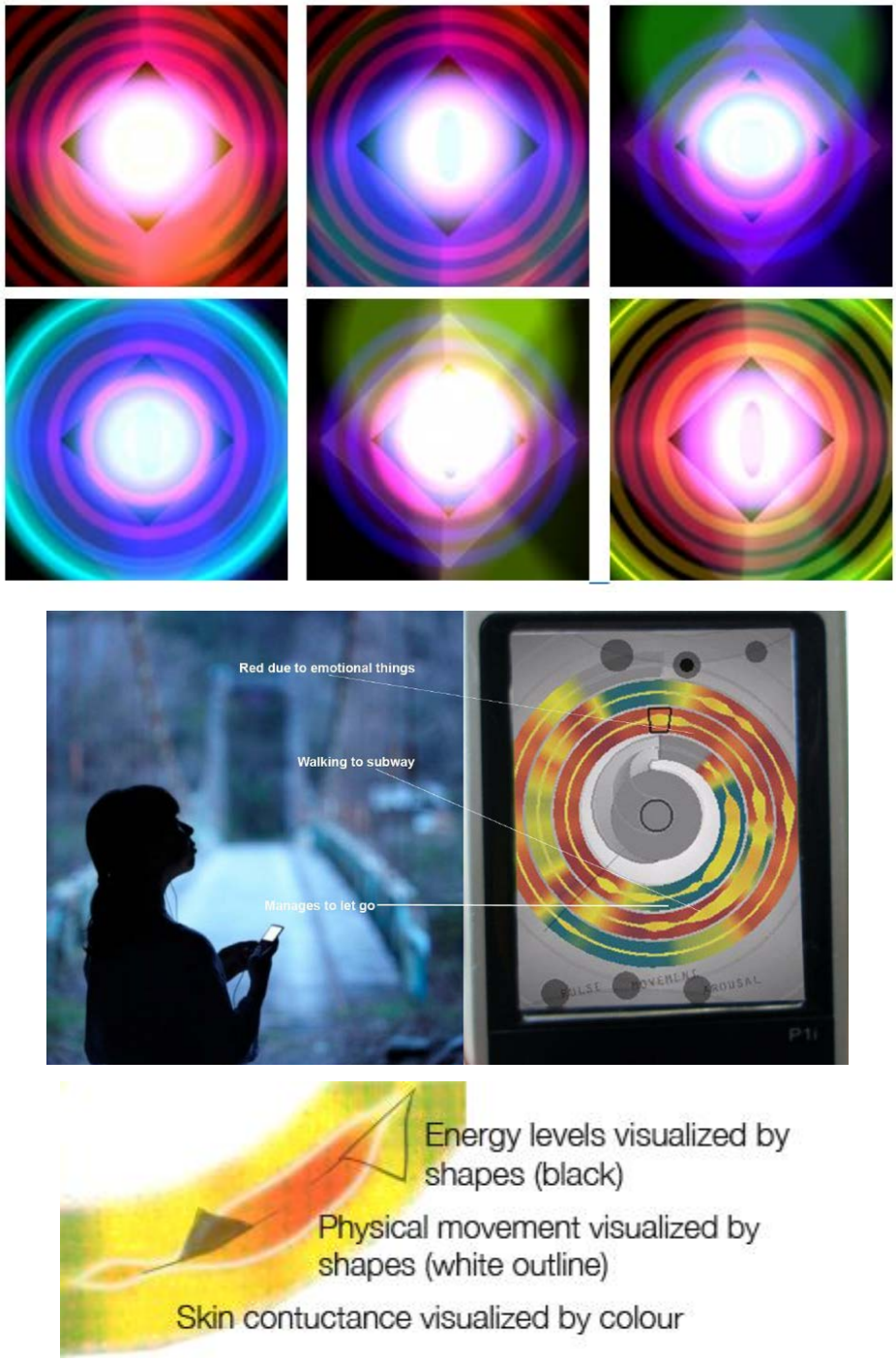

Fig 4.2.2.1 Data Visualisation from Khut et al.'s *BrightHeart* (2011) and Vaara et al.'s *Affective Health* (2010)

II. Experiment with Visualisation Techniques

As walking meditation involves body movements during the practice, the visualisation would aim to show the immediate changes of body activities while would not absorb users' attention to the visualisation itself. In my experience with walking meditation, the visualisation on the phone would be taken as a 'mirror' that let me be aware of my breathing and walking activities. Therefore, the visual patterns of 'Ambient Walk' shall be simple shapes that users

would understand immediately. As ‘Ambient Walk’ encourages user to practice walking meditation in both indoors and outdoors, it is important that the visualisation shall not ‘distract’ users from deep focusing on their walking activities by attracting users to look at the screen all the time. Which is to say, ‘Ambient Walk’ shall foster users’ attention to their perceptions of the body rather than being immersive in the visual environment the app creates. Therefore, I brainstormed about visualisation design with simple shapes like circles, animated dots in a sequence, waveform blocks and particles (see Fig 4.2.2.2). I implemented each visualisation with Processing 3.0 for Android for quick illustration of breathing and walking activities. The list of visualisation designs include:

Shapes of Visualisation	Responsive Animation
Multiple circles (with the same centre)	increase and decrease based on breathing volume
	pre-programmed to breathing period (e.g. if the detected breathing period is 6 seconds, then the circles increase to the maximum for 3 seconds then decay for 3 seconds)
	respond to breathing period (e.g. if the detected breathing period is 3 seconds which indicated fast breathing, then the circles increase and decrease for a period of 6 seconds to foster slower breathing)
Waveform Blocks	increase and decrease based on breathing volume, continuous plotting blocks from left to right of the visualisation area of the phone screen
	pre-programmed to breathing period (e.g. if the detected breathing period is 6 seconds, then the waveform shows rise and decay for 3 seconds each)

Table 4.2.2.1 List of visualisation designs explored for ‘Ambient Walk’.

Shapes of Visualisation (cont.)	Responsive Animation (cont.)
Dots in a sequence	a dot appears when a step is detected; size of dot represents the breathing volume; plot on screen from left to right continuously
	Three dots in a row; one at the left presents the intensity of inhalation; one at the middle represent the intensity of exhalation; one at the right appears when a step is detected
Particles	particles move around the visualisation area of the phone screen; the size of particles represents the volume of breathing; the moving speed represents the walking pace

Table 4.2.2.1 (cont.) List of visualisation designs explored for 'Ambient Walk'.

When I walked with the three visualisation designs with dynamic circles, I was able to immediately understand the intensity of my breathing activity. The animated circles brought my attention to the fullness of my body when my lungs absorbed and extracted air. When I looked at waveform blocks and dots in a sequence, I saw a continuum of breathing intensity while spent few more seconds to reflect my body state at current moment. When I observed the moving particles on screen, I could reflect my breathing intensity and my walking speed via the size and moving speed of the particles. However, the random movement directions of the particles distracted me from paying attention to how my body felt when I breathed and walked as I tend to stare at the screen to guess the meaning of particle movements. Comparing to my experience with waveform blocks, dots in a sequence and particles, dynamic circles brought my fullest attention to my body at breathing with the least time interpreting the meaning of the visualisation on screen. When the circles grew and shrunk according to my breathing intensity, I was immediately aware of my breathing and sometimes tried to adjust my breathing period (e.g. from 3 steps inhale to 4 steps inhale) to see how the visualisation changed. When the circles grew and shrink in a 'prescriptive' speed (i.e. the period of circle animation is longer when my breathing is shorter), I found myself confused with how the visualisation worked. Therefore, I chose animated circles as the visualisation of breathing for 'Ambient Walk' prototype.

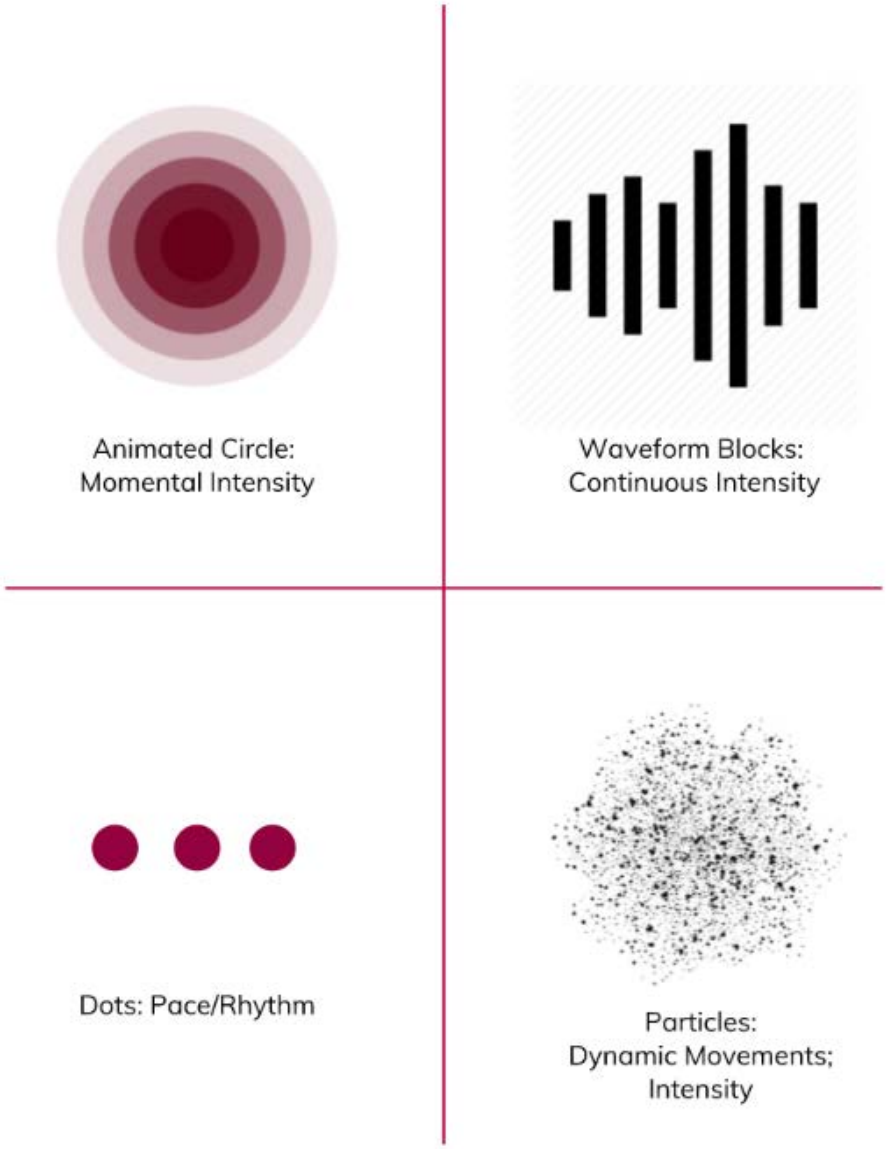

Fig 4.2.2.2 The visualisation options I explored in designing 'Ambient Walk'.

4.2.3 Experiment of Data Sonification

I. Inspirations and Case Studies

During my own practices of walking meditation, I tried to follow the instructions proposed by Thich Nhat Hanh (2006)—highly focused on my self-manipulation of breathing and slow walking. After a while, I found it was difficult to focus on manipulating the balance between breathing and walking as there was no reference for me to reflect on. I started following a music rhythm to perform my breathing and walking, and it was much easier. What if I could create an app to provide this reflective rhythm? In HCI community, a number of researchers

investigated in interactive sonification of body movements. Some involved making devices attached to the body to capture active body movements. For example, Papetti's interactive shoes used low cost speakers to play sound effects generated by the pressures of feet at different positions. Creative practitioners have explored making personal real-time soundscape with human actions and interactions from the surrounding space to bring musical experiences to people's walking activity. For example, Gaye et al. (2003) created the *Sonic City* to bring a personal musical experience by walking and interacting in the city. The *Sonic City* (Gaye et al., 2003) mapped users' activities and spatial contexts in particular places in the city to various layers of musical notes to create a generative soundscape. As there were few examples in creating sonifications for walking, I practiced deep listening myself by highly focusing on listening to my breathing patterns and walking steps in my walking meditation, and imagining the sounds that intrigue and reflect my walking activities.

For deep listening to walking meditation, I began my walking with three-step inhalation and 3-step exhalation like before. Meanwhile, I imagined the pitches and rhythms that reflect and could be provoked from my breath and steps. While I walked I imagined a changing rhythm with single-pitch beats. The rhythm could be faster to prompt me to walk faster when I felt bored, and slower when I was too tired to walk fast. On another day, I began performing walking meditation with a set of imaginative harmonic tones and rhythms. After performing walking meditation every day for a week, I found that I had a stronger awareness of my breathing and walking when the two paces reached harmony (for example, walk two steps per inhalation and two steps per exhalation). Even when I started walking at my usual pace (the pace at which I walk to the lab), I could still obtain a strong, visceral feeling of my body movements from the imagined rhythms. Based on my deep listening experience, I made several simple sonification designs in PureData to be explored for 'Ambient Walk' prototype.

II. Experiment with Sonification Techniques

In creating the sonification of 'Ambient Walk', I identified the feature of my breathing and steps in walking meditation to decide which sound feature to map with. From my own experience of walking meditation, the breathing has a continuous inclining/declining behaviour. While walking steps happen at single time points with a rhythm. Therefore, the sonification of breathing could be mapped with continuous sounds and the steps could be mapped with beats. I made several PureData (Pd) patches with the following sonification designs:

1) Two oscillators (sin waves) with frequencies mapped with breathing period (sec) and walking pace (steps/10 sec) and single-pitch beats mapped with steps;
2) One oscillator with volume mapped with breathing volume and single-pitch beats mapped with steps;
3) Two oscillators with volume mapped with breathing volume, frequencies mapped with breathing period and walking pace (steps/10 sec) and single-pitch beats mapped with steps;

After making these sonifications, I load them onto my Android phone and performed 1 minute walking to see how the sound reflect my breathing and walking activities. When I listen to 1) and 3), I felt how my breathing and walking synchronized according to the pitches from my left ear and right ear--the pitches will form a harmony when my breathing and walking matched a ratio, otherwise not. The single-pitch beats prompted my steps as they became faster when I walked faster deliberately. When I listened to 2) and 3), I found the volume towards breathing volume was less prompting--I felt I was breathing out when I heard some increase of the sound, even that was mapped to my inhalation. Therefore, I considered option 1) as the initial sonification design of 'Ambient Walk'.

4.2.4 Design Specification of the Prototype

'Ambient Walk' aimed to explore interactive meditational practice with users' daily exercise of walking. Inspired by walking meditation practice, it regards walking as playing an instrument that generates ambient music with two layers, mapping the respiratory rate and steps detected by a sound sensor and accelerometer. The two layers of sound may achieve a harmony when the respiratory rate and steps are of a certain ratio, as expected in walking meditation practice (see Fig.5). When users start the application and move away, they will notice the combination of the ambient sound, separately from their left and right ears. Meanwhile, users inhale deeply for a number of steps, then release body tension. When users notice changes in tones, they will walk and breathe more slowly, for a slower beat to calm them down, and walk/breathe faster when they hear a faster beat. The sound design aimed to reflect and stimulate bodily movements while drawing their attention to the current moment.

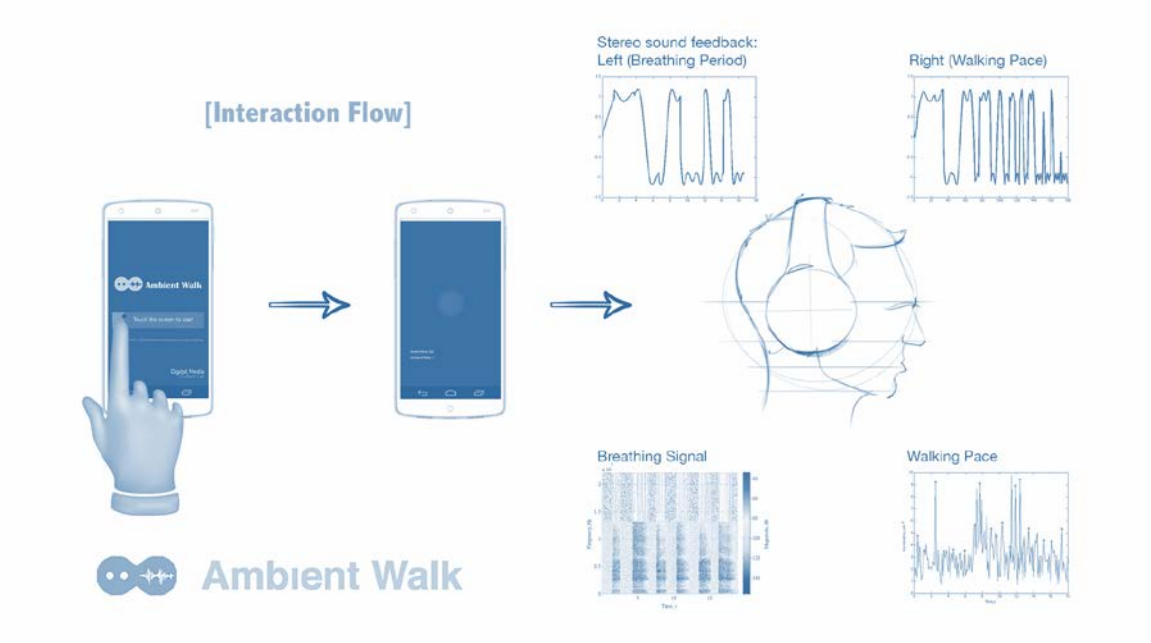

Fig. 4.2.4.1 'Ambient Walk' interaction flow

To reinforce the above experience, I designed an immersive sound space that enhances users' attention to their bodily activities, i.e. breathing and walking. I used the microphone and accelerometer on a smartphone to detect breathing and walking data. The application 'Ambient Walk' was developed for Android phones (OS version 4.1.2+). The minimum requirement for the phone was a 3-axis accelerometer function. To avoid interruption of data sonification, I recommended the use of headphones. Based on the experiments with various devices discussed in Section 4.2.1, I chose to use wired on-the-ear headphones with phone microphone for the 'provotype' as the phone microphone was able to capture breathing sound with better sound quality and minimum latency comparing to other headphone-microphone combinations at the time of prototyping (in early 2015). The development phase of 'Ambient Walk' consisted of two stages: i. the detection of breathing period and steps and ii. the composition of the cartographic sound effects of users' walking data (Chen et al. 2015).

To detect users' breath naturally during walking, I used a microphone incorporated into the phone itself to capture the sound of breathing. By comparing a number of biofeedback sensors and devices (see Section 4.2.1), an integrated microphone is more accessible to users as it requires no additional equipment. To obtain an optimised detection, the microphone must be kept at a distance of 10 cm from the user's mouth (Lu et al. 2012).

To measure the breathing period with the breathing sound captured, we first processed the envelope of the band-filtered sound signal. In Lu et al.' (2012) s breath detection model, the envelope of the temporal respiration data can be approximated by a sinusoidal wave with absolute values, where a full period (i.e. twice of the time between two consecutive peaks) represents a full length of breath. Therefore, we determine the breathing period by detecting the time between two amplitude peaks determined by the average environmental acoustic amplitude.

To determine steps I analysed a sample data collected from the 3-axis accelerometer and gyroscope on the phone. According to Susi et al. (2013), gyroscope data is mainly generated by the swinging of your arm/leg or the movement of your hand that holds the phone, which provides less essential information within the step patterns. Hence, I used the accelerometer to detect the step occurrences. Each step was marked at a local peak of the magnitude calculated by the 3-axis values that is higher than the temporal average acceleration. To yield the results from small-range movements, e.g. the movement of the phone, I set an absolute threshold to filter small movements and a de-bouncing period of detection was set to avoid peak redundancy.

The composition of data sonification reflects users' relaxation status and the harmonic relationship between their breathing and walking. It constructs a stereo soundscape that enables a holistic sensory experience that one can explore, perform to or actively respond to. In the initial prototype, I explored a combination of harmonic pitches as the offset to be multiplied with detected breathing and walking paces, and a variation of amplitudes denoting the temporal intensity of breathing. A responsive pulse sound was also applied to the sonification for users to follow, which become faster when the user walked fast and slower when the user walked slowly.

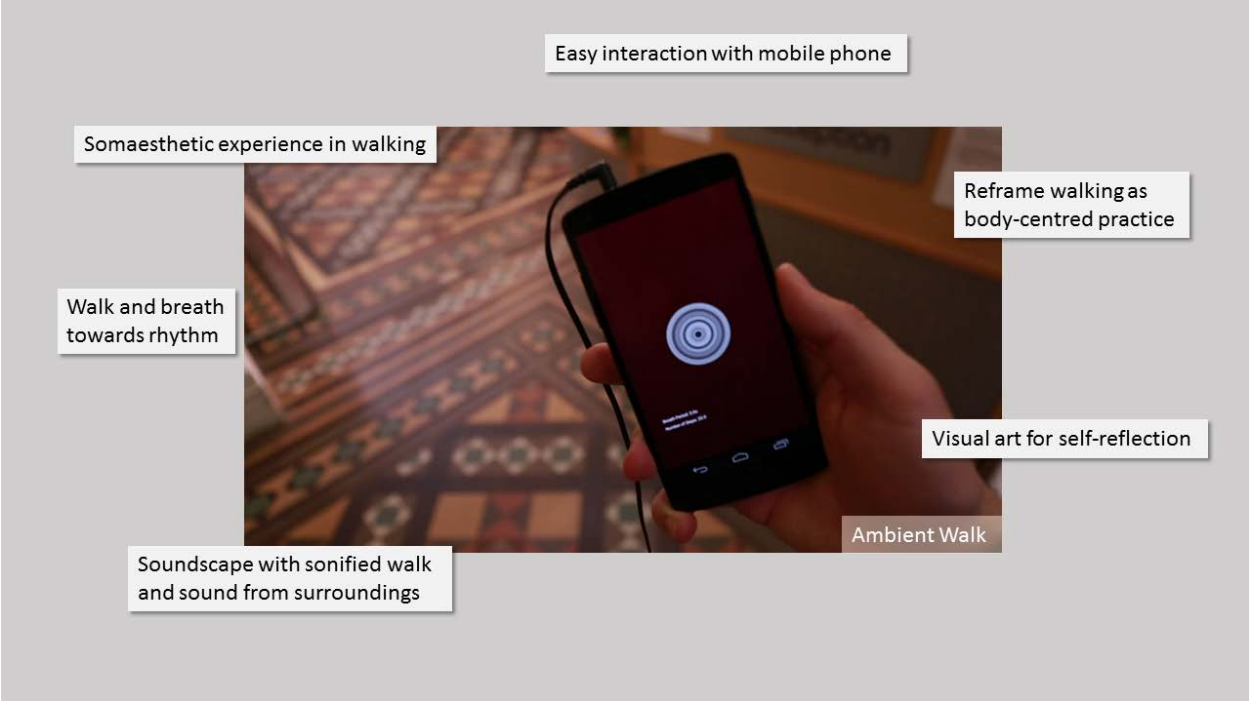

Fig. 4.2.4.2 Annotated presentation of 'Ambient Walk'

In making the sound design for the first ‘Ambient Walk’ prototype, I started by making simple tones and rhythms that mapped breathing and walking data. The tones achieve a harmonic melody when my breathing and walking are kept at the same ratio. I also applied a monotone beat to respond to the walking pace which reflect how fast I walked – the beats get faster when I walk faster, and gets slower when I walk slower. The initial attempt of ‘Ambient Walk’ helped me in engaging with walking meditation, and becoming more aware of my living body while I was highly focused on observing and performing my walk, without dwelling on other thoughts. But would other users experience mindfulness while using it? I brought ‘Ambient Walk’ to the Interactions Gallery to explore what affective experiences other people would encounter with my prototype.

4.3 Initial User Engagement at the Interactions Gallery

To explore the provocative effect of ‘Ambient Walk’, I conducted an initial study with an gallery setting at an HCI conference. Two demo phones with over-the-ear headphones were provided at the exhibition stand, wirelessly connected to a screen illustrating the real-time intensity of users’ breathing and walking detected by the app. The demonstration of ‘Ambient Walk’ had a high level of exploratory visitor engagement. Participants picked up a demo phone with a headphone at the exhibition stand, breathed towards the phone’s microphone and walked around the exhibition venue. I observed the participants’ behaviour, discussed it

openly with them to understand their expectations and what they felt had occurred while using the app. After that I asked open-ended questions and recorded their spoken comments to investigate what connections users found between the acoustic feedback and their walking activities, what feelings and bodily experience they had and how would they like to use 'Ambient Walk'. I selected the video recordings and comments from nine participants to be further analysed (while others only tried the app for less than one minute). The documentation audio and videos were transcribed with notes of participants' non-verbal actions. A thematic analysis (Braun & Clarke 2012) was conducted to generate the following themes relating to participants' experience of use: engaging affective experience, the sound quality and sound-activity relationship, and awareness of the surroundings. Quotations from participants that are representative of the themes, are anonymised in the section that follows.

4.3.1 Exploring Somatic Experience

When participants put on their headphones, the acoustic response prompted their curiosity about how it reacted to their breath. This led to their initial exploration of sound alterations over their breathing and walking. At the beginning of 'Ambient Walk', all participants tried a slow walk in the exhibition area. When they noticed the constant sound pattern, they explored a detour around the building by walking to the corner, turning around and/or stepping downstairs and upstairs. After an approximately five-minute walk, they either sat down or stood still around the exhibition stall. Within the nine participants, participant T noticed an obvious sound change when she turned her body and walked to another direction. (Participant T: *"It doesn't change much at the beginning…When I moved to this corner, it starts changing"*). Participant AD held the phone very close to the mouth, swinging his full body left and right to see what graphics/sound changes would happen in 'Ambient Walk'. Participant DC asked what to do to use the app, tried deep breath (2 seconds approx.) for a few seconds at the exhibition stand, then began walking around the venue slowly. DC also tried walking at different paces and turning around in the crowds to manipulate the sonification and visualisation of 'Ambient Walk'. Participant K tried to figure out how the app captures breath. Stand still and listened to the sound for a while, walked slowly around the hall holding the phone in hand tightly to mouth after been instructed. However, due to the crowds and high noise levels at the conference venue, other participants noted the difficulty of breath detection (e.g. they have to hold the phone very close to their nose/mouth to capture their breathing) and engagement of body movements with the sonification. Therefore, many

participants didn't notice major changes of sound patterns throughout their practices. The difficulty of noticing any changes in the sonification of 'Ambient Walk' suggested further exploration of the sonification design, including richer sound effects with better reflections of the walking and breathing data (further discussed in Section 4.4).

Participants also encountered calming and relaxing experiences. Five participants commented on the calming effect of the soundscape generated by 'Ambient Walk' (*"It's really calming."; "I guess it's to make you calmer."*). One participant commented that he tried to sleep and encounter ASMR[4] while using 'Ambient Walk'. The participant perceived the sound of 'Ambient Walk' as a stimuli that "whispers to my ears" that triggered a stronger relaxation sensation from his body while walking slowly. Although many participants commented on their moments encountering increased attention of their walking bodies and higher awareness of their body activities, it was difficult to prove participants have encountered mindfulness states. This is because participants encountered moments involving value judgment like trying to understand the visual and sound responses to their body movements, identifying whether the app was working or the sound was changing and/or comparing 'Ambient Walk' with other practices such as meditation and ASMR practices. The findings of non-mindfulness moments used engaged with 'Ambient Walk' could be regarded as novel user experiences that increased our self-reflection of the beauty of the body movements in walking, which is in the ground of somaesthetic experience besides mindfulness.

4.3.2 'Taking in' the Surroundings: An Initial Concern

Referring back to the discussion in Chapter 2, somaesthetics appreciation design does not limit to cultivating inward-focused experiences, but rather take bodily interactions with the surroundings as an important factor of our bodily experiences. One participant at the Interactions Gallery highlighted the importance of 'taking in' the interactions from the world 'out'. Full immersion into meditation experience could potentially led to an anxiety of not knowing the surroundings:

[4] ASMR (Autonomous Sensory Meridian Response) is a sensational phenomenon of a tingling, static-like sensation across human upper body, sometimes towards further body areas caused by specific audio and visual stimuli. ASMR is widely reported together with relaxation experiences and well-being (Barratt and Davis, 2015). Example audio-visual stimuli of ASMR phenomenon could be whispering and low voice talking.

"I find it quite challenging for meditation practice that it takes out the outside sounds. It's challenging as meditation requires you learn to listen to some natural sounds but not what's there, which puts the barrier…I think it's dangerous to not knowing what's going on, like, you're isolated in a place without knowing what's outside."

This participant's comment on their experience with 'outside sounds' opened up an alternative perspective of seeing interactions from the surroundings in designing for somaesthetic experiences. This inspired a design confrontation to the occlusion of the interactions from the surroundings in the design iteration, in which users would be informed by the surrounding acoustics together with the sonification of their activities. The sonification layer was taken as an open space that cultivated user attention to the sonic feedback that strengthened user attention and awareness of both the 'inside' of their physical bodies and their bodies' interactions with their surroundings.

4.4 Revised Interaction Design with Sound Artists

At the Interactions Gallery, some participants found out that the phone microphone was not be sensitive enough to capture breathing sound when the microphone was not close enough to one's mouth or the environment was noisy. Participant C suggested that *"If you have a microphone that you can wear closer to your mouth (i.e. headset) it might captures breath(ing) better"*. Participant K wondered what the app would do while she breath to the microphone *("I don't know if I've breathed into the microphone. Was it (the sound) meant to change the brainwave?").* Participant S mentioned that walking and interacting with 'Ambient Walk' was *"a bit odd"*. This feedback prompted use the microphones that could be attached to the ideal distance towards users' mouth with acceptable sound quality. As my previous experiments with different combinations of headphones and microphones (see Section 4.2.1) were configured in a relatively quiet environment, where the accuracy of breathing data recognition and sound quality may be different from the findings from my previous explorations in Section 4.2.1. Therefore, I referred to my experiments with different microphones and selected two types of headsets--an on-the-ear headset with microphone integrated very close to the earpieces and a pair of in-ear headphones with integrated microphone close to the users' month. I tested each headphone-microphone combination with 'Ambient Walk' while walking in the street where the noise level was around 40-70dB. During my walking with selected devices, I found out that the sound quality of breathing recording was similar among the two options when I walked in a place with average street

noise. Both headphones chosen in this design iteration picked up clearer differences between breathing sound and the sound from the surroundings comparing to the sound picked up by the phone microphone. As different participants may prefer different types of headphones, either headphone with integrated microphone could be adapted in the revised interaction design of 'Ambient Walk'. As one purpose of 'Ambient Walk' was to let users engage with audio-visual augmented walking meditation with the devices they already have or with minimal purchase, the users were instructed to use their own headphones with in-line microphones or borrow my chosen headphones during the one-week user study.

Apart from the choice of devices for 'Ambient Walk' prototype, participants at the Interactions Gallery commented about the sonification design as "I hear the sound but I didn't see much difference. Maybe it picks up too much another sounds in the environment." Participant T found the sound "*doesn't change much at the beginning…When I moved to this corner, it starts changing"*. Participant D wondered whether the sonification would make users confused as listening to ambient sound mapping to one's breathing and walking could be an unfamiliar practice (*"Do you think you'd be confused by the sound (of the app)?"*). Another participant wondered whether there were certain states identified based on the breathing rhythm (*"What is the logic of associating the sound with the breathing rhythm? Is there a certain state?"*). These feedbacks suggest some explorations of different sonification mechanism to better represent the constancy and variety of breathing and walking activities. Participants of Interactions Gallery also commented on the timbre of the sonification as metallic (*"I think it sounds more like metallic at the moment."*) or mechanical (Participant A: *"So I'm wondering if you're doing more technical, or mechanical sound ..."*). Additionally, Participant A suggested that "it would be nice to find a balance between 'nice to listen to' and 'soft', at the same time it makes you awake and alert". These user feedbacks suggested some further exploration of sonification design of 'Ambient Walk' with richer sound layers, balanced effects between relaxing and alerting, and interesting sound mappings that would provoke stronger awareness or interesting reflections of breathing and walking activities.

To explore various ideas of sonification design, I collaborated with Tim Shaw and Tom Schofield, two creative artists and researchers in digital arts within the Digital Cultures

research group, to create a number of sonification designs with Pd Vanilla[5] with different creative interpretations of breathing and walking activities. Tim Shaw created his sonification of walking with periodic ambient pulses made with four high pitches, among which the second pulse is longer than the other three in one loop. The period of the ambient pulse reflects users' walking rhythm. Apart from the ambient pulses, Tim also created a layer of high-pitched fast beats at a fraction of users' walking pace. Tom made his sonification of breathing with replays of 'stretched' breathing sound recordings of the lengths of detected breathing periods. When I explored walking meditation with the combination of Tim and Tom's sonification, the ambient pulses not only prompted me walking towards or deliberately against its rhythm but also provided a musical experience that made me enjoy and more engaged with my walking. The stretched sound recordings of breathing created a dramatic response to my breathing activity. At one moment the replay of recorded sound made me feel that my breathing was 'stretching' the time and made everything around me happened slower or faster according to my breathing lengths. However, the replay of my breathing sounds sometimes confused me about how the sonification reflects my breathing when I breath towards a constant length. Therefore, I added a layer of sonification design with single-pitch oscillator that arrives and decays accordingly to my breathing periods concurrently with the replay of recorded sounds as a background-layer representation of breathing activities. To create a stimuli to prompt the walking pace for walking meditation, I added a layer of beats which reverse-mapped to the detected walking pace.

After making the revised prototype, I conducted a one-week autobiographical study to explore what somaesthetic experience could be achieved. The diary of my one-week study is as the follows:

Day 1:
I started walking with 'Ambient Walk' at lunchtime in my office. It started with a regular rhythm in my right ear, roughly 1 beat per second. I tried to breathe into the microphone on the phone and started to hear echoes and wave-like sounds in my left ear. I walked at a normal pace.
I wondered how the beats would change while I walked. So I slowed down my steps. The rhythm changed. Instead of getting slower like my steps, it became faster, like an audience was clapping faster to make me dance faster. I was trying to maintain my slow walk but my arms and legs couldn't help following the fast rhythm.
After a while, I decided to walk towards the rhythm. The wave sound in my left ear was shorter and more frequent – like my breathing. Interestingly, the beats in my right ear

[5] Pd Vanilla: a PureData version that is supported by LibPd for Android that allowing sound artists to integrate Pd patches with Android apps

changed from fast ticks to slower, peaceful ticks – like a hurrying man slowing down his running to maintain a balance. I do not remember what I was thinking, but I was immersed in feeling my breathing and walking. For example, I noticed my feet tend to rise low to save energy. My arm usually moved before my leg when I made a step.

Day 2:
Today I started the app when I walked in the streets near the campus. I breathed to the phone until I heard the ticks and waves. After a few seconds I heard the voice from the previous second replayed for a period of time – not repeating but lasting slightly longer. Before I went out of the building I could hear my breathing to adjust my pace. However, I could barely hear my breathing when I was in the street. The app seemed to be catching my breath as the wave-like sound in my left ear was still there. I started breathing towards the wave sound.
Unlike in the building, I needed to pay attention to the buses, the traffic lights and the crowds. These brought my attention away from my body. Yet after a few seconds, I found a harmony between the traffic ambience and the sound in my ears – they were like a street orchestra in 'August Rush' instead of unpleasant noise. The beats become slower when the cars moved fast, telling me to calm down. The waves sounded slow and relaxed, which made me calmer in the busy street.
On my way back to the campus I heard an explosion (perhaps from a tyre), which distracted me from my walking. The continuous sound immediately took me back to 'Ambient Walk', which relieved my shock about the explosion.

Day 3:
When I walked indoors, I was more focused on detection and rhythm. The wave sound changed frequently when I tried different breathing lengths. I could feel the sound mimicking the movements of my lungs – expanding and shrinking regularly. Later on I paid attention to the sound changes when I ran upstairs and downstairs. I ignored the beats when I was in a hurry until the beats became very slow, which notified me that I should slow down. When I slowed down, the beats became more noticeable and regular.
When I walked outdoors, I didn't pay much attention to detection but followed what was going on. I usually have a busy mind when I walk in the streets. However, I did not think about anything else but paying attention to the sound.

Day 4:
Today I used 'Ambient Walk' after a busy day. I spent a long time thinking before I started my walking. When I heard the beats from the app, my attention was driven away. I was curious about the soundscape layer even though I've heard it many times – every time the sound is similar yet different. I felt my perceived world had expanded from what I could see or hear. I was so curious about my discovery that I forgot the question I was thinking about before.
When I stopped the app, I felt relaxed and joyful.

Day 5:
Today I felt the sound was repetitive, as it was not much different from yesterday. I was a little bored so I kept looking for something new. I tried breathing fast and slowly, walking towards different directions with different speed. I found out that if I walked normally (2 steps per second), the beats would be extremely slow so that I needed to move my legs as if in slow motion. I felt my walking had stretched my perception of time – the time passed slower when I walked faster. The breathing sound changed very frequently when I breathed fast, which balanced my perception of time.

Day 6:
Today I tried walking without the app and with the app in the same place. Like usual, I had a lot of thoughts running through my mind. I kept thinking about them when I walked without the app, so I didn't notice my surroundings. However, when I was using 'Ambient Walk', I noticed it amplified the environmental ambience – I noticed people talking along the way, the frequency of the cars in the street and the sounds made by my shoes. I forgot to check the data on the screen but keep breathing to the phone and walking because I enjoyed the ambience.

Day 7:
When I finished my lunch I felt a need to relax. My earworm was repeating the wave-like sound and beats so I picked up my phone to have a walk with 'Ambient Walk'. When I started walking I heard the familiar sound, yet it seemed different than how I remembered. I could feel the pressure when my foot hit the floor. The sound reminded me how strong my footprint was. I usually don't pay attention to the doors in the building but today I noticed them very quickly. I must have a stronger attention to my surroundings than before.
Later on I noticed my legs and arms were sore because they were held longer than usual when I followed the beats. I sat down and walked again when the beats became faster.
Overall I enjoyed using 'Ambient Walk' as I had a stronger feeling of my bodily movements of breathing and walking, and these movements are beautiful. I always feel happy and relaxed after using it, so I will definitely continue using it in my life. Moreover, although the sounds are similar on different days, I can always discover something new in my walking.

4.5 Empirical User Study

Based on the initial findings from the observation at BritishHCI Interactions Gallery, I conducted a one-week user study of 'Ambient Walk' to evaluate its usability and effectiveness in engaging mindfulness over time, on a daily basis. Using a Snowball sampling method, I recruited four participants, Fay, Julie, Cheng and Vivian (pseudonymized herein)[6], who are mindfulness teachers and/or regular practitioners. They took part with informed consent in accordance with an approved ethical protocol. Fay and Julie borrowed my headset as they did not have compatible devices in hand and preferred on-the-ear headphones. Cheng and Vivian used their own headphones with in-line microphones. At the prototype stage 'Ambient Walk' was not published onto app market for users to download. Therefore, participants used the Android phone that I provided with 'Ambient Walk' already installed. Each participant used 'Ambient Walk' for at least five minutes every day during one week. They were guided to walk according to the sonic feedback during their practice. At the end of the study, each participant completed an online questionnaire with questions regarding their attention, relaxation experience and a description about when they obtained a conscious state like mindfulness. I used a qualitative approach in our analysis to investigate individual

[6] To protect participants' privacy, all the names being used in result and discussion of this chapter are pseudonyms.

experiences throughout the weekly trial of ‘Ambient Walk’. The analysis mainly focused on the provoked user experience of ‘Ambient Walk’ regarding user attention, bodily experience (sensational and physical) and awareness of the self and surroundings.

4.5.1 On Attention and Bodily Experience

Regarding the attention shifting effect of ‘Ambient Walk’ as a proposed mindfulness practice, Julie indicated that the sound had caught her attention and distracted her from her ongoing activities, yet the generative sound was not what she preferred. On the contrary, Fay and Cheng noted that the sonic environment generated by the app helped them focus on their walking from the third day onwards. Furthermore, Fay realised a difference in her focus before and after her walking meditation with the app as the practice *“enabled her awareness of these (distracting) thoughts and let them go.”* On the last day, she *“would have been lost in thought much more because of distractions outside”* if the sonic feedback had gone.

Reflecting on her experience, Fay found ‘Ambient Walk’ augmented her awareness of the body in terms of bodily sensations and reduction of thoughts *(“The added dimension of sound meant that there was an additional sense for the mind to focus on (as well as physical sensations), and therefore the attention to thoughts was reduced significantly.”).* From the second day, she noticed a stronger feeling of her bodily movements in both a static position *(“The second day that I used the app I began to find myself fully immersed in the experience. On this occasion I was in a room on my own and I began in a stationary position and brought my attention to my whole body first (a body scan).”)* and a dynamic movement during her walking practice *(“I then began by taking very slow steps up and down the room. The sound helped me to focus my attention on my feet and legs walking. This experience of strong attention on the experience of my body walking continued throughout.”).* Vivian went through a process of “exploration and realisation” when she was trying to understand how the sound reacted to her bodily experience. She also noted that the sound was clearly reacting to her bodily rhythm in breathing and walking *(“The right one changed rhythm according to my walking pace.”).*

4.5.2 On Perceptions of 'Thoughts'

During the study, participants had different perceptions of 'thoughts' while using 'Ambient Walk'. Fay perceived thoughts as unwanted, distracting her from her mindfulness practice *("As the days progressed I felt that the sounds accompanying the walking helped the process of the mind not being distracted by thinking – it felt that I was in a more enclosed world and this kept my attention focused.").* Thus she emphasised 'Ambient Walk's effect on reducing her attention to thoughts. Likewise, Cheng also referred to thoughts as a source of unwanted distraction, finding that 'Ambient Walk' helped her to focus on walking and not thinking about other things. However, Vivian saw thoughts as important activities concurrently with her walking *("I found sometimes the sound of the app distracted my thoughts."*). Vivian found it important to perceive the interactions from her surroundings, like the changing relative positions towards other people and objects on the way *("Walking to work. The sound seemed to distract me from (noticing) natural sounds e.g. car horns, birds etc.").* Therefore, Vivian sometimes neglected the sonification while she was walking and thinking *("I wasn't fully immersed by the sonic background. I sometimes neglected the sonic while I was walking and thinking.").* The 'thoughts' in Vivian's context were not only her thinking on other events dwelling from the past, but also her perceptions of surrounding environment that affects her walking activities. 'Ambient Walk' was designed to foster users' perception of their body activities at the here and now, without lingering to the thoughts about other events in real life or the interpretation of meanings of visual/sound patterns. In Fay's experience, 'Ambient Walk' had brought her attention away from the thoughts of real life events. However, she also voiced experiences of trying to interpret the meanings of sound patterns. For example, she tried to understand whether 'Ambient Walk' captured her steps correctly at one time. On another day Fay also thought about sounds other than her breathing ("*The microphone was sensitive enough however to pick up other sounds such as a cough, a sigh or hair rustling around the microphone or other exterior sounds...which was confusing at times…*") was not helping her to focus on her mindfulness practice. These thoughts about the meaning of the sounds have brought Fay and Vivian away from a no-value-judgment mindfulness experience.

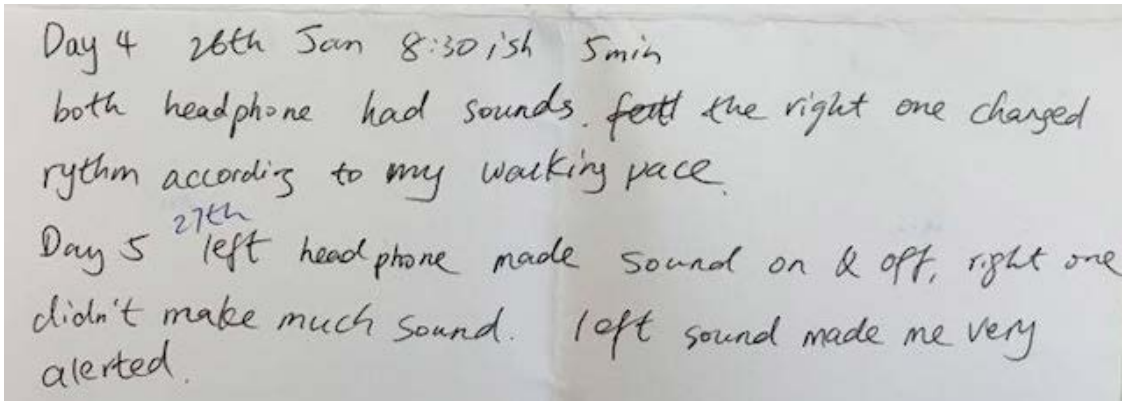

Fig. 4.6.2 Vivian's diary of her experiences with 'Ambient Walk' as a listening journal.

4.5.3 On Mindfulness and other Somaesthetic Experiences

Participants reported on their mindfulness experiences with ‘Ambient Walk’ with reduced thoughts, higher awareness and focus of their body activities in walking. However, some participants also encountered somaesthetic experiences that were not mindfulness experience when such experiences involved value judgment. The non-mindfulness somaesthetic experiences include users’ interpretation of their extended sensation or awareness of their body activities while interacting with their surrounding environment. Fay used ‘Ambient Walk’ with a Body Scan and found Ambient Walk strengthened her mindfulness experience. However, she also found the sound of surroundings distracted her from her practices. As discussed in Section 4.5.2, the moment Fay thought the sound of surroundings were not a reflection of her body activity is not a mindfulness moment as it involved self-interpretation of the meaning of the sound. In mindfulness practices, practitioners were instructed to observe and keep their attention to their body activities (such as breathing and steps) and how their activities reflected by the surroundings (e.g. the touch to the earth). In my autobiographical practice with ‘Ambient Walk’, I walked and breathed towards the visualisation on the screen and the sound I heard without thinking about how to react to the visual/sound presentation. ‘Ambient Walk’ was a ‘mirror’ that made me highly aware of my body movements while focusing on the audiovisual layer, but not a medium that let me dwell in interpreting the meaning of the sound or manipulating my walking to see the changes in the sound patterns. However, participants of the empirical study tried to think about interpret what a sound/visual

pattern means or how would they react to the rhythm. For example, Vivian and Cheng shift their focus between ‘Ambient Walk’ and their thoughts on the way. From time to time Vivian tried to interpret how the sound from ‘Ambient Walk’ represented her body activity. There were times Vivian perceived that ‘Ambient Walk’ produced noise therefore she was less engaged with the app while walking.

4.5.4 On ‘Taking in’ Bodily Interactions with the Surroundings

For Somaesthetics Appreciation design (Höök et al. 2016), designers sometimes create a separate space for practitioners is created to focus on their body and mind to obtain a strong somatic experience of the self. The separate space helps practitioners to focus on the feelings of their body and responses from the design artefacts. Apart from the inward-focused experience, somaesthetic experiences also include perceptual bodily experiences during people’s interactions with their surrounding environments apart from ‘a separate space’. In making the first ‘Ambient Walk’ prototype, I created an ambient soundscape that aims to bring people’s full attention to their bodily movements and focus on the responses of the sonification layer. This somehow created a separate space where users shifted their attention from perceiving events around them to the sound representing their breathing and walking. At Interactions Gallery, some users of ‘Ambient Walk’ highlighted that full immersion into one’s inward experience could potentially lead to anxiety about not being aware of one’s surroundings. It is important to be aware of interactions with the world outside of our body. According to user feedback from the empirical study, preferences for taking in the interactions with the surrounding environment are diverse for each participant. Some prefer an environment to create intrinsic, self-centred body awareness for high focus. Others prefer an environment to cultivate extrinsic, environment-connected body awareness with focus on the current moment.

As individuals who prefer a private space for mindfulness practice, Fay and Cheng both engaged a stronger, concentrated bodily experience within the separate space created by ‘Ambient Walk’ as it strengthened their awareness of body rhythms in real time. When ‘Ambient Walk’ provided sonifications from users’ interaction with the surroundings, Fay was confused while exploring the sound-movement relationship *(“The microphone was sensitive enough however to pick up other sounds such as a cough, a sigh or hair rustling*

around the microphone or other exterior sounds. These sounds would then be played back in a loop for a minute or two, which was confusing at times…"). From the perspective of 'taking in' the body interactions with surroundings, Fay encountered a stronger reflection of her bodily activities that were usually not noticed. Vivian noted that her immersion in 'Ambient Walk' distracted her from noticing the traffic lights, bus roars, etc. In this situation it is crucial to link the inward bodily experience to the surrounding environment to strengthen the awareness of both.

4.6 Discussion

'Ambient Walk' cultivated user attention by its sonification layer that extended users' hearing experience. The design inquiry of 'Ambient Walk' provided a practical study that grounded the design knowledge of somaesthetics from its empirical findings; given an example of making provotypes to explore digital art with biofeedback technology for mindfulness and other somaesthetic experiences; and led to a re-accented direction of engaging somaesthetic experience with awareness of the surroundings in addition to the inward-focused practices. The research findings provided evidence to explore what bodily experiences participants encountered during their use of 'Ambient Walk', looking at how we design for walking meditation with data visualisation/sonification and biophysical sensing technology. The findings from the empirical study (stated in Section 4.5) unveiled that participants of 'Ambient Walk' did not fully engaged with mindfulness experiences. Meanwhile, many user feedback with non-mindfulness experiences could be seen as somaesthetic experiences from actively interpreting, reacting or improvising body activities (E.g. Fay actively performed some body scan activities to act to the visualisation/sonification of the app ("*I began in a stationary position and brought my attention to my whole body first (a body scan)...I then began by taking very slow steps up and down the room.*")). The active interpretation, reaction or improvisation was reinforced by 'Ambient Walk's visualisation and sonification layers, which could be seen as an extended sensation of the body activities. These phenomena inspired me to re-accent my further design practice to look into the extended territory of designing for somaesthetic experience--adding a 'sixth-sense' to enhance our aesthetic perception of body in the interactions with the surroundings. Section 4.6.1 will discuss the findings from the two user studies (at the Interactions Gallery and the one-week empirical study) showing how 'Ambient Walk' cultivated somaesthetic experiences in walking by visualise and sonify users' body activities with vis-a-vis interactions with the surrounding

environment. Specifically, how users' engagement to non-mindfulness experiences in 'Ambient Walk' contributed to the re-accentation of my design exploration to engage somaesthetic experiences from mindfulness practices to activities that 'add a sixth-sense'--extend users' perceptions and sensations of their body activities. Section 4.6.2 will reflect the practical methods I applied in making 'Ambient Walk'--autobiographical explorations to collect design resources and making 'provotypes' to explore novel somaesthetic experiences users may engage, and how these methods would be applied in making 'Hearing the Hidden'.

4.6.1 From Mindfulness to Adding Sixth-Sense: Extending Design Space after 'Ambient Walk'

Many mindfulness practices suggest removing practitioners from outside interactions, and the reason is to avoid distractions so that one could focus on one's feeling in the body at the 'here and now' (Claessens 2009; Vidyarthi et al. 2012; Chittaro & Vianello 2015). While we see interactions from the surroundings as part of bodily interactions, bringing practitioners' focus away from the interactions from their surroundings would provoke a level of unawareness of the ongoing surroundings that may lead to a fear of isolation (Simons 2015). Many somaesthetic design practices created physical boundaries to foster inward-focus somaesthetic experiences. For *Sonic Cradle (Vidyarthi et al., 2012),* a dark chamber was selected to reinforce a media immersion experience as a spatial boundary for self-reflection of individual breathing activities towards the soundscape. When we refer to Shusterman's definition of somaesthetic experience, we could see somaesthetic experiences include aesthetic perception of our bodily activities (such as body movements in breathing and walking) towards our body interactions with the surroundings. 'Ambient Walk' did not create a physical boundary for bodily interactions in walking meditation, but created an audio-visual layer that fosters user attention to both their breathing/walking activities and their interactions with the surroundings. This was because in walking, a somaesthetic experience involves not only high awareness of your biophysical activities from the inwards, such as your breath and your muscle tense, but also your body reaction to other pedestrians on the road, the bus roars that makes you alert, etc. These interactions from the surroundings may enhance users' awareness of the current moment by reflecting the interactions from the surroundings as part of their bodily experience. The design concept of 'Ambient Walk' was not to form a completely virtual space to separate users from the physical world, but to shape their attention to their bodily sensations within themselves and the reality at the current moment. We saw

somaesthetics as not only about sensing the body within oneself, but also sensing the body in the world.

According to the user feedback from the Interactions Gallery (stated in Section 4.3) and the empirical user study (stated in Section 4.5), participants have reported their moments of mindfulness experience when they observed the altering visualisation and listened to the changing sound towards their walking pace. For example, Fay found out that *"Having the headphones on felt like I was enclosed in another world and this was the element that enhanced the (mindfulness) experience"*. Some participants have obtained higher awareness of their body activities reflected by the animated circles of 'Ambient Walk' showing the breathing and the sound patterns representing the walking activities. While such awareness of body activities are not mindfulness experiences when participants began interpreting the meanings behind the visualisation and sound then deliberately react to such interpretation. For example, Fay stated that *"On days 1, 2, and 3 I was confused by this and had to restart the app a couple of times in order to get rid of the unwanted sounds…I tried holding the phone initially and then decided to put it in my trouser pocket, assuming that by being close to my legs it would be most accurate but I am not sure that this worked very well"*. Cheng encountered a moment of higher awareness of her changing walking pace through a sudden 'noisy' sound (*"On day 3, I was distracted by a noisy sound in my left ear. But I figured out that the noisy sound was caused by the moving of the device at a fast pace while walking on that day."*). The moment Cheng noticed and tried to understand the cause of the noisy sound is not a mindfulness moment as it involved value judgement such as 'whether the noise means I did not follow the app properly'. While Cheng's increased attention to the noisy sound and realisation of its relation to her fast walking pace can be seen as an enhanced somaesthetic experience by extending her perception of the body.

From the perspective of extending our bodily experience, 'Ambient Walk' altered individuals' walking experience by letting them 'hear what we may not notice otherwise'—users may not be able to notice their walking pace in everyday walking, while 'Ambient Walk' cultivated users' awareness of their walking pace and intrigued users' exploration of how their breathing and walking altered the soundscape. At the Interactions Gallery, participants actively explored various body movements (such as walking with different paces and turning into different directions) to see how the visualisation on the phone screen and the sonification changed accordingly. Many participants have also actively acted to the data visualisation they have

seen and/or the sound they have heard. For example, participant AD held the phone very close to the mouth. Then he breathed evenly and swung his full body left and right, trying to alter the sonification responding to his breathing and steps. Participant DC tried deep breath (2 sec approx.) for 1-2mins at the exhibition stand. Then walked around with various speeds and towards various directions. While *Soma Mat* and *Breathing Light* (Stahl et al., 2016) extended users' somatic experience by making stronger heat sensation at different body parts or mimicking breathing activities with changing lights, 'Ambient Walk' extended users' somatic experience by adding a layer of soundscape to reflect users' walking activities. This extended sensation and perception of our bodily interactions in walking could be compared to Dag Svanaes' practices that extended people's somaesthetic experiences by 'adding extra body parts' (see *Wag your Tail and Flap your Ears* by Svanaes and Solheim (2016)). Dag Svanaes (2013) mentioned Merleau Ponty's example of blind person's cane to argue that *"the body has an ability to adapt and extend itself through external devices (p8:10)"*. Svanaes and Solheim (2016) created a mechanical tail and a pair of mechanical ears with embedded motion sensors for the performers to wear at theatre plays. The tail and the ears vibrated and moved based on the performers' body movements. Performers preferred to take control of the mechanical tail and ears with their body movements as this gave them the experience of having external body parts. From the perspective of enhancing somaesthetic experience, the additional body parts (i.e. the tail and the ears) have added a 'sixth-sense' that extended performers' perceptions of their body movements by adapting the external body parts. In the case of 'Ambient Walk', the mobile phone app provided an 'external device' for the users to adapt and extend their body through listening to the sonification and looking at the visualisation of their body activities, i.e. the breathing and walking movements. Comparing to Svanaes and Solheim's *Wag your Tails and Flap your Ears* (2016), 'Ambient Walk' did not provide external body parts, but provided a soundscape layer that extended users' awareness and adaptation to their body activities.

4.6.2 How 'Making Provotypes' Helped in Designing for Somaesthetic Experience

In designing for experiences, it is crucial to understand the aspects from both the individual and the interactive system that may affect the provoked user experience (Bødker 2014). In the case of designing for somaesthetic experiences, designers have conducted literature review of inspiring areas of practices (e.g. *Soma Mat* (Stahl et al., 2006) was inspired by somatic

practices such as Feldenkrais), collected design sources with autobiographical studies (e.g. *Soma Mat* and *Breathing Light* (Stahl et al., 2006)) or co-design sessions (e.g. *Sonic Cradle* (Vidyarthi et al., 2012), made design artefacts or prototypes and conducted user evaluation to evident the kind of experiences were designed for. The purpose of 'Ambient Walk' study, instead of providing a functional application for mindfulness practice, was to provoke users' somaesthetic experience in a body-centred everyday practice like walking. Somaesthetic experiences are distinct among individual users. For example, some users of *Soma Mat* may feel relaxed when a particular part of the mat was heated up, while other users may feel tense and alert due to the temperature. In the case of 'Ambient Walk', some users achieved mindfulness experiences when they observed how the sound respond to their walking activities, while other users actively explored changing their walking activities (such as walking faster or slower deliberately) to see how the sonification changed. These individual bodily experiences were exposed by providing users a 'provotype'.

As a 'provotype', 'Ambient Walk' exposed different bodily experiences based on users' pre-understanding of mindfulness that resulted in different expectations/ways of performing with the app. At the Interactions Gallery, many participants explored 'Ambient Walk' by percieving the breathing/walking data, the visualisation/sonification patterns and potential feelings that occur in its use. While in the empirical study, mindfulness practitioners explored their bodily feelings via 'Ambient Walk' by practising mindfulness. For example, Fay performed a 'body scan' while using 'Ambient Walk'. She expected 'Ambient Walk' to be a creative representation of the traditional mindfulness practice that she was aware of. Julie was expecting a mindfulness practice with natural sound, yet she experienced mindfulness moments with higher awareness of her living body (when she was more aware of her bodily movements while walking her dog), which she did not highlight as a mindfulness experience. The 'provotype' has also unveiled that users may engage non-mindfulness state when they obtained value judgment moments while walking with 'Ambient Walk'. In my own practice of walking meditation with 'Ambient Walk', I walked faster and slower without intention to explore how the sound would change towards my pace. Instead, I focused on observing my walking activity reflected by the variations of rhythms and animated circles on the screen. However, many participants in this study tend to explore how the sound/graphics would change over time by altering their walking behaviour. This kind of experiences were different from the mindfulness experience of *Sonic Cradle* or *MindfulHu* (Zhu et al., 2017) that involved highly-focused observation of the soundscape in the dark chamber or the changing

illumination of MindfulHu device.

In both the observation at the Interactions Gallery and the empirical study, participants noted the moments when they engaged with enhanced somaesthetic experience, regardless of the accuracy of the data. For example, Fay was not certain about the accuracy of steps in a moment, but she felt that she was more aware of her feeling of her bodily movements when she did a 'body scan'. The sonification of users' activities has the potential to provoke a stronger awareness of their walking activities, bringing their attention away from distractions. As a 'Provotype', 'Ambient Walk' allowed users to listen to their activities, be more aware of their breathing and walking via the response from the soundscape, and potentially foster their somaesthetic experience towards their everyday walking. By making the 'provotype' of 'Ambient Walk', I was able to find out the variety of somaesthetic experiences users have engaged when we combine data sonification/visualization, biophysical tracking and walking meditation. Moreover, the 'provotype' of 'Ambient Walk' has unveiled that users engaged with non-mindfulness experiences which were novel somaesthetic experiences (for example, extended the perception of body activities through the sonification) that could be explored further. The findings of these novel experiences contributed in re-accenting my research purpose into exploring HCI design to extend somaesthetic experiences by 'adding a sixth sense'. The design space of my research is then expanded from 'designing for somaesthetic experience with mindfulness practice' to 'designing for somaesthetic experience by adding a sixth sense', with inspirations from Svanaes and Solheim (2016)'s design practices that add 'extra body parts' and Bird et al. (2008, 2009)'s research projects to create sixth sense experiences such as *Feel the Force* (Bird et al., 2008) and the *Low-Fi Skin Vision* (Bird et al., 2009).

Chapter 5: Hearing the Hidden: Adding Sixth-Sense Experiences via Bodily Interactions with the Surroundings

This chapter, ‘Hearing the Hidden’ extends the research exploration that began with ‘Ambient Walk’. ‘Hearing the Hidden’ is a wearable application that generates a responsive soundscape to strengthen users’ somaesthetic experiences via their interactions with the surrounding environment. The soundscape of ‘Hearing the Hidden’ adds a 'sixth-sense’ experience as a kind of somaesthetic experience – the extended perception of users’ body activities by ‘hearing the unheard’—reflecting their interactions towards the surroundings alongside their inward self-reflection. In this chapter I will describe: the lessons learnt from ‘Ambient Walk’ that inspired the re-accented exploration of adding a sixth-sense to extend somaesthetic experience; the concepts and practices that inspired ‘Hearing the Hidden’; the design process with exploration of different devices, visualisation and sonification designs; the observation of user engagement at the 'Loop, Layers, Lines' show (Culture Lab, 18.03.2016); the design iteration to enhance users' ‘sixth-sense’ experiences and the user study to evaluate how ‘Hearing the Hidden’ cultivated ‘sixth-sense’ experiences; how the practical design methods adapted in ‘Hearing the Hidden’ contributed to HCI design for extended somaesthetic experience; and how ‘Hearing the Hidden’ extended and re-accented the initial design space specified in Chapter 2.

5.1 Re-Accent from Mindfulness to Adding a Sixth-Sense: Lesson Learnt from ‘Ambient Walk’

Many design practices of *Somaesthetic Appreciation Design (*Höök et al., 2016*)* involved creating a ‘separate-space’ as the boundary of interactions to enhance an inward-focused somaesthetic experience. *Sonic Cradle* (Vidyarthi et al., 2012) formed a ‘separate space’ with the dark chamber, the hammock for participants to lie in and the soundscape based on participants’ breathing patterns. *Soma Mat* formed a ‘separate space’ with the yoga mat and *Breathing Light* created a ‘separate space’ with the hanging lamp and shade (Stahl et al., 2016). The creation of ‘separate space’ in *Somaesthetic Appreciation Design* did not suggest neglecting bodily interactions with the surroundings. The concept of considering body-in-the-world experiences in HCI design could be referred back to Höök (2009)’s citation of Merleau-Ponty’s statements about the body: *“The body is not an object. It is instead the condition and*

context through which I am in the world." (Merleau-Ponty,1962; cited in Höök, 2009, p3593) For *Soma Mat* (Stahl et al., 2016), users reflect their somaesthetic experiences via interacting with the yoga mat by sensing the heat response activated at different parts. 'Ambient Walk' did not have a spatial boundary to form a 'separate space' like *Sonic Cradle*'s dark chamber (Vidyarthi et al., 2012) or *Breathing Light*'s hanging lamp (Stahl et al., 2016). Instead, I created the soundscape and graphical visualisation as a virtual 'self-reflection space' to bring an inward-focus of their walking activities. At the Interactions Gallery and one-week user studies, users commented that it was important to retain a high level of awareness of the surroundings. For example, when one is practising walking meditation on the way home, one should be aware of the traffic alongside one's breathing and steps. During the one-week empirical study, participants have also engaged with somaesthetic experiences that were not mindfulness experiences e.g. the interpretation of the visual/sound feedbacks, preference of the sound effects or curious reactions to 'Ambient Walk'. While we look at these non-mindfulness experiences from another perspective, the perception of the visual/sound feedbacks extended our awareness of the participants' breathing and walking activities, and the curious reactions to 'Ambient Walk'. Thus this research was re-accented from somaesthetic design with mindfulness practice to somaesthetic design by 'adding a sixth sense'. In Section 5.1 I will discuss the lessons learnt from 'Ambient Walk' that suggested to explore designing for somaesthetic experiences through engaging bodily interactions with the others and surroundings, and how my research re-accented from somaesthetic experience with mindfulness practices to adding a 'sixth-sense' to enhance somaesthetic experiences.

When refering to the concept of bodily experience, Columbetti (2013) argues that 'body' and 'bodily experience' are not only an affective experience within the physical body, but also our body states during the interaction with the surrounding environment. In body-centred practices such as Mindfulness (Hanh 2010) and Deep Listening (Oliveros 2005), both encouraged a reflection of what's happening inside and outside of the human body. Take walking meditation as an example, Thich Nhat Hanh (2006) not only encouraged practitioners to focus on their inhale and exhale within their physical body, but also to pay attention to the events happening on their routes. When we refer to Pauline Olivieros' (1979) *Deep Listening* practices, they suggested keep aware of things happening around the practitioners to cultivate awareness and empathy, which could be the environmental sounds from objects and other practitioners in the same place. Interactions from the external environment may 'distract' practitioners from focusing on their in-vivo activities, but they may not 'distract' practitioners

from their mindfulness or deep listening practices. Indeed, awareness of our interactions with the external environment is a part of these practices that could cultivate a stronger awareness of our body movements and feelings while practicing walking meditation. In my autobiographical study to collect design sources for 'Ambient Walk', the feeling of my feet tapping on the ground reflected my walking pace and intensity. The environment sound such as bus roaring and cars passing by brought my focus to my walking directions, the speed of my feet moving and the nervous feeling of my body when I encounter moving vehicles or pedestrians on the way. As 'Ambient Walk' focused on exploring in-the-body experiences such as breathing and body movements while walking, it is necessary to explore body-centred practices under the context of strengthened awareness during our bodily interactions with the external environment, where awareness of the surroundings is crucial and contributive to cultivate bodily experiences. 'Hearing the Hidden' is then designed to explore such experiences in body-centred practices.

'Ambient Walk' achieved 'higher awareness' and attention to the current moments, while users also obtained thoughts and perceptions of the meaning of the sound/graphics towards their walking activities and tried to comprehend how to response to the sound/visual cues. As mindfulness is a state of centred awareness of the current moment without judgments or dwellings (Kabat-Zinn, 1990), the moments of obtaining meanings of sound/visual patterns are not mindfulness moments which 'observe and accept things that are happening' without value judgment. Comparing to existing HCI designs for mindfulness practices, 'Ambient Walk' did not fully achieve the purpose of cultivating users' mindfulness experiences. For instance, *Sonic Cradle* (Vidyarthi et al., 2012) allowed users to observe their breath through listening to the soundscape. With 'Ambient Walk', users not only observed their breathing and walking through the animated circles on screen or the sound patterns, but also tried to comprehend the meaning of the sound pattern, react or even improvised their breathing/walking activities to explore the alterations of the sound. Comparing to *spheres of wellbeing* (Thieme et al., 2012), 'Ambient Walk' was not designed to be integrated into clinical mindfulness practices, but adapting walking meditation as a practice to alter users' somatic experiences in everyday activities. Therefore, 'Ambient Walk' is not positioned as a design example of HCI design for mindfulness practice. The purpose of this research is then re-accented to designing for stronger somaesthetic experience, using walking meditation as an example body-centred practice to foster users' perception and feelings of their body activities.

At the Interactions Gallery and the one-week empirical study, users reported some moments when the visualisation and sonification of 'Ambient Walk' extended their perceptions of the breathing and walking activities. Participants' experiences of exploring walking towards rhythmic sound feedbacks can be compared to Hajneijad et al.'s *GangKlang* (2013), which involved making external devices (i.e. the shoes with force sensors, vibrating motors and speakers) to alter users' walking experiences by actively listening and acting towards the sonic feedbacks. From the perspective of extended somaesthetic experience, 'Ambient Walk's sonification provided an external layer that added extended sense towards user's' walking activities by strengthening the reflections and interactions towards breathing and pace of walking, which may otherwise be ignored in everyday walking. 'Ambient Walk' can be seen as an extra device that added a 'sixth-sense' towards user's' walking activities. Such 'sixth-sense' experiences can be referred to Dag Svanaes' design practices (e.g. *Wag your Tail and Flap your Ears* by Svanaes and Solheim (2016)) to explore altering somaesthetic experiences by adding body parts. Svanaes and Solheim (2016) explored extending performers' perceptual and sensational experiences of their body by adding a mechanical tail in theatre play. The tail was designed to bring a visceral tail-wagging experience to the stage performers by mapping the tails' mechanical feedbacks towards performers' body movements denoted by the accelerometer and gyroscope data. When the performer tried to control the tail by moving his/her body, the motion sensors on the tail map the performer's movements to pre-programmed kinetic feedbacks. Therefore, the performer perceived the tail as an extended body part that strengthened his/her aesthetic perception of his/her body movements together with the mechanical tail, which could be regarded as a 'sixth-sense' experience. Other practices that fosters somaesthetic experience by 'adding a sixth-sense' include Yvonne Rogers and her research group's projects such as *Tactile Car Seat* (Bird et al., 2008), *Feel the Force* (Bird et al., 2008) and *Low-Fi Skin Vision (Bird et al., 2009).* For *Feel the Force*, the designers made a 'light sabre' with haptic interactions to enable users' 'sixth-sense' of the force--the extended sensation to determine the location of a virtual flying robot. Users were able to engage with extended sensitivity and perceptual experiences of their body movements through the virtual space formed by a virtual robot, the motion sensors and vibration units mapped to the location of the robot and the motion of users' arms. *Low-Fi Skin Vision (Bird et al., 2009)* added a sixth-sense to allow blind-folded users to 'see' and 'hit' a moving virtual ball based on their haptic sensations. Comparing to *Feel the Force* (Bird et al., 2008) and *Low-Fi Skin Vision* (Bird et al., 2009), 'Ambient Walk' did not create virtual objects such as the 'light sabre and robot' in *Feel the Force* (Bird et al., 2008) or the 'bat and ball' in *Low-Fi*

Skin Vision (Bird et al., 2009). Instead, 'Ambient Walk' created a soundscape that augment users' somatic experiences mapped to their body activities and their interactions with the surrounding environment. The cultivated awareness of breathing and walking activities from 'Ambient Walk' app can be compared to the increased awareness of the locations of surrounding objects related to the driver and the vehicle from Bird et al.'s *Tactile Car Seat (2008)*. This finding from 'Ambient Walk' together with inspirations from Svanaes and Solheim (2016)'s and Bird et al. (2008, 2009)'s design practices has contributed to re-accenting my research exploration from 'engaging somaesthetic experience via mindfulness' to 'engaging somaesthetic experience by adding a sixth sense'.

5.2 Deep Listening and Echolocation

As an extension of 'Ambient Walk', 'Hearing the Hidden' explores the possibility of fostering somaesthetic experiences by engaging a 'sixth-sense' towards what's happening in the surroundings. The first step is to allow the users to engage with an activity that could enhance one's perception of the surroundings with extended sensibility, and easily connect them with their own bodily experiences during the self-reflection thus to be fully involved in this process. But how do we design to create such 'sixth-sense' experience? What practice can not only bring user attention to explore the surroundings, but also help them connecting their 'sixth-sense' with the surroundings to their own somaesthetic experience?

When we talk about listening in everyday context, we usually think about listening to music or speech. Ambient sound, especially those subtle frequencies from the surrounding environment, is usually ignored or sometimes filtered as unwanted noise from our listening experience. Ambient sound from the surroundings, e.g. traffic light signals for pedestrians or cars on the road, is regular and rhythmic. It sometimes helps us perceive important actions of the sound source. When I listen to pedestrians' step frequencies, I could tell how fast they walk and potentially how hurry they were on the way to their destinations. By doing so, I could adjust my pace to get off their ways, or even synchronise with their pace to form a harmonic rhythm. In Deep Listening, Olivieros (2005) suggested listening activities such as *"actively listen to the sound, actively imagine sound, actively create sounds"*. But which situation may help in cultivating people's awareness of their body movements by augmenting their perception of the surroundings? Which practice may encourage deep listening and mindfulness via engaging a stronger body and environment awareness?

Human Echolocation, initially introduced for the visually impaired, is a listening practice for actively estimating the layout/obstacle location at a place under limited vision (Flanagin et al. 2017). It is inspired by the distance detection method used by the bats and dolphins i.e. 'hearing' the distance by detecting the time difference between the sound source and the echoes. People who practice echolocation are able to tell the distance to the sound sources via the echoes and/or reverberation from self-generated sound, such as tongue clicking. Professional practitioners may also be able to tell the texture and the emptiness of the object they perceived. To achieve this, one shall obtain a professional training regarding the best method to generate the self-initiated sound and techniques to identify the qualities of echoes representing the qualities of the objects detected. Whether we could create digital sonification that augment echolocation to make people more aware of the objects in the surroundings thus they have a stronger perception of their body movements, feelings and intentions?

In the second RtD study of my doctoral project, I explored an interactive design piece that cultivates somaesthetic experiences by adding a 'sixth-sense' – augmented echolocation experiences. I proposed the design of 'Hearing the Hidden' to explore a 'sixth-sense' of people's bodily movements via seeing and listening to the layout of the space they are in. By understanding the echoes and purposeful-generated sequences, users would perceive the distances towards nearby objects to become more aware of their body movements, and perceive their body movements that fostered their affective experiences (such as emotions and feelings of their body) to inform further actions. In Section 5.3 I will outline the design of 'Hearing the Hidden', including the user scenarios that were considered, the design and technical specification of the ultrasonic hat developed as an exploratory design, the data sonification techniques, and the visualisation. In Section 5.4 I will discuss about the findings from the user experiment of 'Hearing the Hidden' under different situations, regarding body awareness and attention, the 'sixth-sense' bodily experiences users encountered, the perceived role of their bodily interactions reflected by the changes of their surroundings and experiential differences between 'Hearing the Hidden' in the dark room and that in the bright room.In Section 5.5 I will summarise a short discussion based on the findings of 'Hearing the Hidden' user study with brief annotations of its contribution to the extended design space that was expanded out from 'Ambient Walk'.

5.3 Designing the 'Sixth-Sense' Experience with Autobiographical Study

5.3.1 Stimulate the 'Hearing the Hidden' Experience: User Scenario

'Hearing the Hidden' is designed to add a 'sixth-sense' to extend users' somaesthetic experiences—raising body awareness by strengthening one's perception of interactions from the surrounding environment. Users who engage with 'Hearing the Hidden' begin with understanding the distances towards nearby objects, realising one's body position and walking directions and having intentions for further body movements. The 'sixth-sense' experience would be *'users knew the object is close when they hear shorter gaps between the echoes'*. To reinforce this 'sixth-sense' experience, 'Hearing the Hidden' prototype will record and generate echoes of the environmental sound from the surroundings, with the time gaps between original sound and echoes being proportional to the distances to the nearest object (s) in the surroundings.

During the first design specification, I created a simple PureData patch to generate echoes with the time gaps mapped to the distances to nearby objects at the left and right sides of my body. While I explored various time-distance ratios to reinforce the awareness of my body's distances to nearby objects, I discovered that the echoes for short distances were usually hardly heard. Therefore, I added a layer of pulsing sound to notify users about nearby objects which the echoes cannot be heard. The user scenario has then become 'users knew the object is close when they hear shorter gaps between the echoes, and users hear a high-pitch pulsing sound when they encountered an object of very short distance'. For the specification of user scenario and interaction flow, users would obtain their 'sixth-sense' experience (in this case, extending their sensations and perceptions of their body in the surroundings by listening to the changing environment in the surroundings while walking) by active listening to two layers of sounds--the echoes of recorded sound of the surroundings and the beats occur at short distances when the echoes would be hardly heard. When the user starts the application and moves away, he/she notices the starting beep and a lower base tone when no object is in the detection range. When the user comes closer to an object, he/she hears a high pitch pulsing changing towards their walking direction. The pulse becomes faster when they come closer to the detected object, or slower when they walk away (detailed exploration of sonification design see Section 5.3.3). The sound design aims to make the users think about their body movements, their feelings of the body and their surroundings. (see Fig. 5.3.1).

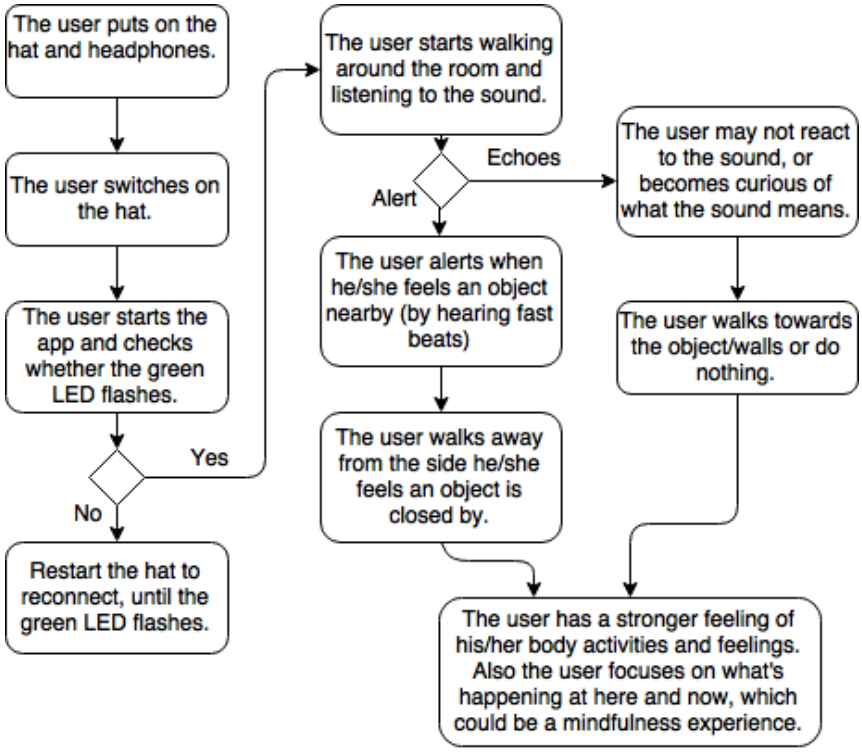

Fig. 5.3.1 User scenario of 'Hearing the Hidden'

5.3.2 Designing The Ultrasonic Hat

In echolocation, people perceive the distances to nearby objects by estimating the time between sound source and echoes. Therefore, distance detection is one of the main technologies to be used in ‘Hearing the Hidden’. Ultrasonic sensors and Infra-red sensors are two widely used modules in distance-sensing technologies (Mustapha et al. 2014). Ultrasonic sensors detect distances by generating impulses of ultrasonic signals in every few seconds, longer than an interference period when the sensors were waiting for the feedback signal. It can be used to detect distances in various conditions including places with limited light (Amin & Borschbach 2017), where brightness was crucial for Infra-red sensors. Therefore, ultrasonic sensors are ideal to detect objects under visual-limited scenarios. For ‘Hearing the Hidden’, the sensors shall be able to detect the existence of objects at point-positions within a short

range, while the detection of the size of objects were much depended on the movements of the user. Therefore, I designed the ultrasonic hat which uses ultrasonic sensors to detect distances to nearby objects within moderate distances (<4m). The locations of the ultrasonic sensors attached to the user's body could affect the user's 'sixth sense' towards his/her body interactions reflected by the changing distances towards surrounding objects. Therefore, I explored attaching the ultrasonic sensors at different parts of my body and recorded my perceptual experiences with the following options:

1) Two ultrasonic sensors to be attached on the left and right side, at the height of human head
2) Two ultrasonic sensors to be attached on the left and right side of the shoulders (at the height of torso)
3) Four ultrasonic sensors to be attached on the front, left, right and back, at the height of human head, with spatial panning of the echoes.

For both option 1) and 3), I could easily estimate the distance to the objects on my left or right side. While I tested option 1) and option 2), I found out that the sonification of option 2) had more noise than option 1). This was because in my walking habit; my shoulders had more movements than my head. When I tested option 3), I found out that the echoes from left and right sides were clearer for me to distinguish, while the echoes from front or back were harder to be distinguished. Therefore, in making the device for 'Hearing the Hidden', I used two ultrasonic sensors to be worn at the left and right sides of my head, which formed the 'provotype' —the ultrasonic hat.

The ultrasonic hat has two ultrasonic sensors on both left and right sides of the rim. They are connected to a Cactus Micro 2 with embedded ESP8266 WiFi module for real-time wireless data transmission with the Android app. Each ultrasonic sensor can detect objects within 400 centimeters. The sensors would send and receive ultrasonic signals every 1 second, including the time between the sent/received ultrasonic signals and data transmission among the sensors and the Cactus Micro board.

Fig. 5.3.2 The ultrasonic hat. Image: S Chen

5.3.3 Sonification for Body Interactions with the Surroundings

As a main intervention medium for ‘Hearing the Hidden’, the sonification aims to expand users' somaesthetic experience by strengthen users' perception of the distances to the objects in their current environment. By enhancing the perception of distances, the user shall be able to estimate the position of the sound source (i.e. either the nearest object is at the left or the right), the distance towards the object and whether the object is very close to them. The linear distance between the sound source (i.e. the detected object) and the user is represented by three sound qualities: the delay of the echoes, the amplitude and the pitch.

The echo layer synthesses the delay of echoes and reverberation according to the distances. In human echolocation, people mainly perceive these features via the qualities of echoes/reverberations from their self-generated sound (Flanagin et al. 2017). People would perceive an echo with lower volume and longer responding time is from a far-away object. Also people are able to tell the direction where the object was located due to the delay of the sound towards the left and right ears.

To resemble the perceived location of the sound source, I used spatial *panning* to 'locate' the sound around the listener. In sonification design, *panning* is a widely used technique to simulate the direction of the location of sound (Pulkki 1997). A simple *panning* technique is to estimate the radius between the sound source to the left ear and the sound source to the right ear, then apply the radius to the gain control of the stereo channels (i.e. the channels for the left ear and the right ear). When the radius to user's left ear is smaller, he/she perceives the sound source at the left of his/her body. The radius is positively correlated to the distance detected.

When users encountered obstacles within short distances, they would hear modulated sound with changing pitch and modulation frequency. The variety of pitch was based on the Doppler effect (Bianchetti & Ganci 1994), which represents the changing effect of sound frequencies according to the moving distances between the sound source and the human ears. When users come closer to the sound source, they would hear a sound with increasing pitch. When they walked away, they would hear a decreased pitch. Fig. 5.3.3 shows the panning of sound in relation to the distance data and potential user perception towards the sonification.

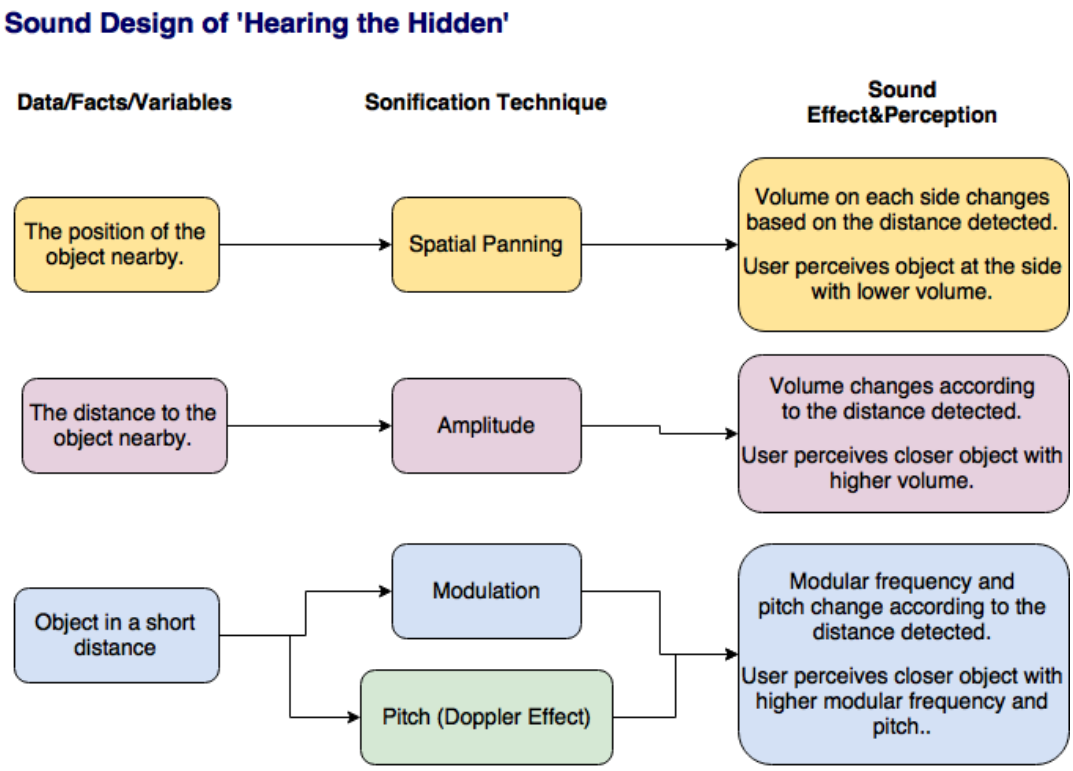

Fig. 5.3.3 Sound design of 'Hearing the Hidden'

5.3.4 Data Visualisation for ‘Hearing the Hidden’

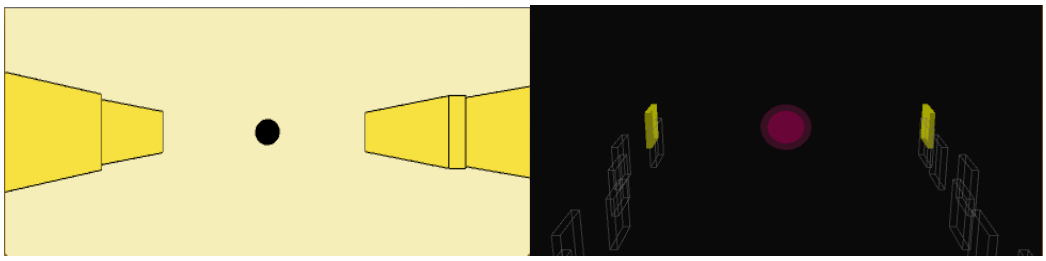

Fig. 5.3.4 Visualisation Concept for 'Hearing the Hidden'

The visualisation of ‘Hearing the Hidden’ on the phone screen is designed to show the existence of obstacles on the move. It provides a reference for the users to observe their body movements in relation to the objects (e.g. walls, shelves, equipment etc.) in the space while perceiving the sound generated by their walking activities. Therefore, the visual interface would illustrate two information—the existence and movements of surrounding obstacles in relation to the user movements.

As seen in Fig. 5.3.4, the circle in the middle represents the relative position of the user in between the obstacles at left and right. It stays in the middle of the screen as a focal point to provide a ‘focus of the self’. The rectangular cubes on the left and right represent the nearest obstacles detected by the ultrasonic hat. Their distances to the circle are correlated to the obstacles’ distances to the user. The cubes will move when the obstacles appear/disappear near user’s walking route. To help users evaluate the changes of the surroundings, five consecutive detections are shown on the screen so that users could see the changes of the layout of the obstacles at previous moments. Therefore, users are able to refer their perceived distance via listening to the sound to the visual representation thus to enhance their confidence of distance perception via listening.

5.3.5 Observations of ‘Hearing the Hidden’ at ‘Loops Layers Lines’ Show

To introduce ‘Hearing the Hidden’ to the public and obtain quick evaluation of potential affective experiences users may encounter, the prototype of ‘Hearing the Hidden’ was demonstrated at the ‘Loops Layers Lines’ show, an exhibition for creative art practices organised at Culture Lab at my University. The devices of ‘Hearing the Hidden’ were provided at the exhibition to allow users to try on while walking around the exhibition venue. Audiences who were interested to walk with ‘Hearing the Hidden’ were instructed to walk

freely with the device around the exhibition room and the corridors. They were encouraged to 'talk aloud' about what they experienced and how they felt during their walks.

During their walking with 'Hearing the Hidden', users expressed their perception of their body locations and the directions they intended to walk to after hearing the sound. When the echoes from each side were distinct from each other, audiences were able to tell the direction they were moving to and had a stronger intention of moving towards/away from the perceived sound source. After three-to-five minutes walking with 'Hearing the Hidden', one user commented that they perceived "an expanded space" in their mind, as 'Hearing the Hidden' extended their sensations of the distances towards the hidden objects in the dark. However, there were times when the audience members were not able to tell their walking directions when the echoes were subtle.

As 'Loops Layers Lines' show is a public exhibition of collective artworks, each audience had limited time to explore 'Hearing the Hidden' due to the availability of the devices. Some audiences also noted that the noise from the venue has interrupted with their perceptual experiences of 'Hearing the Hidden'. Therefore, I conducted a further evaluation of 'Hearing the Hidden' in carefully-set scenarios, including in the dark environment and in the bright environment (see Section 5.4 for details).

5.4 User Evaluation

5.4.1 User Study Design, Participant Recruitment and Data Collection

To explore potential sixth-sense experiences people engage with 'Hearing the Hidden', I conducted a short-term user experiment in the Sound Studio at Culture Lab, which is the easiest venue to be converted in a dark room with excellent sound proof. The experiment observes users' activities in both darkness and brightness to explore the variety of perceptions affected by visible range. Each user had 10 minutes to walk with 'Hearing the Hidden' in the darkness then another 10 minutes to walk with the lights on (each session could be extended to 15 minutes if user requires). Users were instructed to put on the ultrasonic hat and to start the app on the phone. After that they were encouraged to explore the space freely by walking to any directions inside the room. In the end, a 15 minute, face-to-face interview was conducted for each participant to collect their feedbacks on the bodily experience they had

under both situations, their comparison of dark room experience and light room experience and potential mindfulness-like experiences they had encountered.

Before the user study, five participants were recruited randomly from different departments of Newcastle University (2 work in HCI/Computer Science, two from Fine Art/Digital media and 1 from other area) by university email invitations and personal contacts. Each participant has different previous experience with mindfulness practice. Three participants had no fear for walking in the dark while two depended on the situations. I took photographs of use and audio-recordings of interviews with users were anonymised for analysis (with pseudonyms used in this account), and processed with the appropriate ethical responsibility.

5.4.2 Thematic Analysis

In this section, I present the Thematic Analysis (Braun & Clarke 2012b) of participants' interactions with 'Hearing the Hidden'. The analysis produced the following identified themes (from 5.4.2.1 to 5.4.2.6), supported with descriptions of participants' activities and excerpts made through use or in the interview

- Intriguing Exploration of Bodily Interactions with the Surroundings
- Engaging 'Sixth-Sense' Experiences
- Intentional activities
- Full-Body Experiences Complemented by the Sixth-Sense

- Interactions from the Surroundings as Extended Somaesthetic Experience
- How did the surroundings altered the sixth-sense experience?

5.4.2.1 Intriguing Exploration of Bodily Interactions with the Surroundings

As 'Hearing the Hidden' was new to the participants, each participant experienced a level of uncertainty in the beginning of the experiment (Alice: *"At the beginning I was quite unsure, uncertain about what I'm doing, and trying to figure out how the cell phone and app and the sound interact with each other."*). They were uncertain about what would they see or hear from the app, what would the sound/graphics on the screen respond to and how they changed. Alice noted that the uncertainty might make the audiences *"feel a bit unsure and maybe nervous"* when they did not know what would happen next. But such uncertainty has also made them wonder what would happen when they move their body. Alice, J, Dean and Mary experienced a level of curiosity without assuming the meaning of the sound. They enjoyed their process of finding out the meaning behind the sound and the animation on the screen (Dean: *"I kind of enjoy exploring all the stuff in there and try to (figure out) what stuff in the rooms might affect the sounds that I was hearing before. The process itself creates enjoyment because (when) we try to explore, it generates some curiosity inside of me. Like what if (I move) my face? Will it affect my hearing and the sound they're going to generate from the stuff that I'm going to touch and the noise/the sound I'm going to make"*; J: "*Sometimes when the sound comes from (the app), it is really interesting.*") In particular, Alice commented that walking with 'Hearing the Hidden' was like playing a game. (Alice: *"Actually I found this kinda sound is quite playful and interesting. Especially to understand the reaction with images and cell phone app is more like a game."*) When the sound occurred, she perceived that as "*they want me to play more, to explore more, and to try different kind of movements*" therefore the sound *"pushes me to them and makes me more intimate to them"*.

During the walk, three participants had a relaxed experience, while the reason of relaxation varies. Connie found it was relaxing as she was focusing on her actual body movements e.g. breathing (Connie: *"I was more focusing on my breath. Because I was trying to relax...So I was trying to figure it out and then I tried to pull myself back and to focus on my breath again. So I relax a bit.*") Dean has also found 'Hearing the Hidden' relaxing and he continued feeling like to come closer to the objects after hearing a sound. This is because he felt that 'Hearing the Hidden' helped him to *"develop my confidence in terms of what movement (I shall do) to position myself between (among) all the objects in the room. And probably it also*

helps me to get myself more comfortable in the dark room".

Some participants found 'Hearing the Hidden' enjoyable and relaxing at the beginning, but became nervous when they perceived the aesthetics of the sound or what the sound might imply. Mary found the sound was pleasant at the beginning when she tried to understand how the sound reacted to her movements. However, she became irritated by the repetitive sound after she walked around the room for several times. While trying to understand how the sound react to their activities, J felt it was relaxing initially (J*: "once it would be initially relaxing in that"*). But later on she felt nervous when she realized that the sound might try to inform her *"oh well I have to move"* when it came out unexpectedly.

In addition, one participant specified that their extended somaesthetic experience could be affected by the type of objects present in the place. Alice noted that her feeling of walking with 'Hearing the Hidden' would depend on the type of objects in a certain environment. She elaborated that for 'Hearing the Hidden', the objects she found were what should be in the room. Therefore, she felt neutral and relaxed. But if there were something unusual in the room, she would feel strange.

5.4.2.2 Engaging 'Sixth-Sense' Experiences

During the experiment, Alice, J, Dean and Mary became aware of the sound in relation to their walking in a short period of time. Alice found that her sensation "*was more intensified"*, because she had *"to be aware of the surroundings in active way" and "to look for the object around you in case you fell down or stepped on the object"*. Meanwhile, she also had the intention to "play with the distance between the app and the object". Therefore, she gave more attention to listen the quality of surrounding objects from the sound, not only the distance to them but also "the property and the shapes and the sizes of the objects". She felt the different textures of objects through her imagination and previous knowledge alongside the sound patterns (Alice: *"For example, (the box) is quite soft and I can feel it's empty below it. When I put my cell phone next to the glass I can feel it's cold and it's completely different."*).

While Alice focused on perceiving the static quality of the objects in the room, J paid more attention to discover the dynamic changes between her body movements and the changes of object positions. While J was exploring the sound reaction to her walking, she discovered that "*what would happen more often that is if I would walk straight forward into sort like*

unimpeded space, there would be nothing much than just general sort, like the white noise. If I was standing next to items that were on either side of me, that I put sure the lights either sides. But often I'm not sure that...I'm not sure how to even describe it. But if I move back or side to side then it was like moving from ear to ear, like (telling me) 'I'm over here. I'm over there'. So it was kind of like...it was kind like a passage. And the passage was guiding me on." J had "a playful experience" when she discovered the sound was *"danc(ing)"* to her movements. She felt quite playful because it was like *"when you have those piano keys on the floor that you step on, and you make the sound"*. At one moment, J realized that *"looking up or down would make the light and the sound clearer. And that I could see if I would duck down towards an item, it would sort of like...the sound would amplify and swell. And you get different notes come in. So that was quite bodily itself like...you realize that "oh I am controlling this" in this area"*. The sound was emerging from somewhere at something she was doing. *(J: "The sound would spin me round and bring me back."*) Eventually she was more aware of her body—*"more than that was anything else"*. But then J realized that it was actually better for showing where she shouldn't be walking into. The animated graphics on the phone screen together with the sound was *"like an extra guiding hand showing "maybe you don't go over here""*.

While Alice, J and Mary kept their attention on the sound reaction to their movements, Dean initially paid attention to his body movements, from the inside-out. But later on he felt the body and the sound "implants seamlessly". Therefore, he totally forgot about his body movement but just focused on his head's movement. As he commented that " *it's just totally focus on just one point, just my head. And I could remember about positioning the phone on my body. I just want to remember the movement of my head"*. Initially he thought it was *"just going to reflect on the hearts (heartbeats) or breathe or something that could result in the currency of the sound"*. But eventually he found out that *"with any stuff, like even with my hand, I can reflect on that noise"*. He noted that 'Hearing the Hidden' notified him about the existence of an object on one direction, but initially it was difficult for him to identify the distance with the sound. The visual presentation on the phone helped him to identify the distance and actual direction where the objects existed.

Connie only noticed the situations when the sound would change. Initially she was not highly aware of the sound-movement relationship as she was focusing on her body (e.g. breathing).

Later on she discovered the sound was reacting to her movements when she went close to a tall object. (Connie: "*I tried to walk closer to the walls and to the chairs and to some other equipment in the room. And I discovered the closer I walked to a certain area (like the walls) that was higher than certain heights, then I could hear some different sounds…(the sounds) changed when I walked in the process of actually towards one direction. It wasn't necessarily changed when I'd turn to another direction.*") She also realized that the sound from the app depended on the direction she was going to and how closer she was to the objects that reached a certain height. Similarly, Mary focused on understanding the app with limited attention to the dynamic changes of the sound initially. Later she became aware of the sound-movement relationship as *"if my body position is closer to the wall, (means) the sounds is getting stronger, apparently"*. They were more aware of the states of their body, either static or dynamic, towards the reaction of the surrounding objects. She understood the sound reaction was not towards her movements at one position, but her movements to different positions in relation to the objects around ("I think it doesn't matter where I sit or stand, it all matters that if I'm close to obstacles or not.") She also noted her dependence on the app visualisation to tell the actual distances towards other objects, apart from the sonification. (Mary: "*I'm more dependent on this device. Because I realized that it's like the sense detector that helps me to sense the obstacles. If you watch that you will see the difference. But if you don't watch the screen, you won't know the difference...Even though you didn't hear the voice while hearing the sound. But you still know something is kind of close.*")

5.4.2.3 Intentional Activities

While walking with 'Hearing the Hidden', Alice, J and Dean intended to walk towards the perceived objects after they heard the sound. Alice went to the objects because she "*just want more diverse kinds of objects to play with*". She wanted to "*hear more, trying to find some beats/rhythm in that sound*" and "*try different types of objects*". Such reaction was autonomous, "like a chain reaction", as she found it was natural to move one part of her body while she moved another part. J stated that at the moment she heard a sound from the app, she was "actively seeking the sound out", which she thought "*it was probably the right thing to do*". Dean tried to move his head over to "*identify how it's going to affect the sounds and the image on the screen*". He explored the reaction from the visual interface by trying to position himself (like straight towards the stuff). When he understood how the visualisation reacted to

his movements, he tried to locate his head and tried to identify whether if moving close to the objects it will increase the intensity of the sound.

Apart from approaching to the object they perceived via the app, J was also exploring a sound composition by trying different body movements (J: *"At one point I was actively trying to make a tune. Because I was curious as to how it would play out if I was moving backwards and forwards and side to side"*). She bobbed her head around and walked to different directions in the room to create her own sound sequence. She felt it was fun for her when she noticed the sound would go from side to side while she moved.

Apart from the intention of walking towards the objects, Connie and Mary intended to walk away from the perceived position of objects in the room. They indicated that they perceived those objects as obstacles which could be dangerous and interruptive during their walking. When Connie noticed a tune appeared, she felt alerting. Therefore, she walked away from the direction towards the objects. (Connie: "*When I notice that something changed as well on the screen. (It was) kind of alerting.*" "*...I could hear stronger sounds like warning me of the possibility of going against something. So that's why I walked away from that. (The sound effects) not really changed according to (all) my behaviours. But I did recognise when I walked towards something very close. Then I would get some warning sounds so I walked away.*") Mary also explained her intention to avoid the objects she perceived while trying to understand how sensitive the device was (SC: "*Okay, so...when you hear a sound, do you try to come to the thing to explore what's happening or avoid the object?*" Mary: "*Avoid it.*")

In the analysis I considered user intentions at different time points. Alice and Dean kept walking towards the walls, desks, chairs and equipment to see how the sound and graphics change. Connie and Mary kept avoiding walking towards the objects when they heard the sound as "alerts". J tried to get closer to the objects in the beginning, when she actively explored the sound-movement relationship and the composition with her body movements. Later on she thought it was better to avoid those objects when she heard a louder sound after walking towards them (J: "*Initially my intuition was to go towards it. Because I was still kind of figuring out what the application was telling me. So when I see the light and I hear a sound itself, it's like, you know, like a treasure hunt. And I was like 'Oh! There's something over here. I'm going to have a look at'. So initially I was moving towards the places where I was hearing sound and I was seeing the light paths for about a while. But then I figured most of*

my walking on that while, I'm not sure exactly what it is at the side of the room. It would follow my path with the sound and with the light when I was walking straight parallel alongside that. So then every time I turned to it, it would get louder. And it became like 'this is telling me what to avoid'. So I kind of switch from initially like "oh I should go towards the sound" to (like) "this is telling me where I should not be going"."). Therefore, she walked away from the direction to the objects instead of coming closer to them.

5.4.2.4 Interactions from the Surroundings added a 'Sixth-Sense'

When I taked with participants about the role of interactions from the surroundings (i.e. the presence of the objects, the sound generated according to the positions of objects, etc.), all participants indicated that focusing on such interaction would not distract them from cultivating their body awareness and appreciation during 'Hearing the Hidden'. Alice thought "*a distraction is maybe an opportunity to listen to new sound. And that is playful. And I just perceive everything it plays in this room is a part of the work. I will not see them as distractions*". She thought "*(it's) kind of a bodily installation*" as "*in that space, the wall, the floor and every other object make up the parts of the organization of the work. But every part should have their values and roles…So I think this work is not only about the sound/the performance in their motions, it is also about the object and the distance between them*". Therefore, the interactions from the surroundings, like the sound 'made' by the objects in the room, formed a necessary part of her bodily experience in 'Hearing the Hidden'. Dean found out that he does not "feel that I'm superior from the objects or from the things that I performed...I'm a part of it". The sound generated by the distance towards the objects helped him to concentrate and helped him to remember the layout of objects inside the room. While participants noted that 'hearing' the environment was an important part of their bodily experiences with 'Hearing the Hidden', Connie argued that 'seeing' the actual environment and looking at the phone screen can be distracting to her practice.

5.4.2.5 The 'Sixth-Sense' enhanced Full-body Experiences

All participants had a fully-involved whole body experience with 'Hearing the Hidden' through the extended dimension of somaesthetic experience reflected by the surroundings. Connie thought that practicing 'Hearing the Hidden' brought her attention to her full-body perceptions, especially at her breathings more than other practices. For this reason, she paid less attention on other activities in the surroundings but her own body movements towards the sound. Similarly, Dean had an immersive experience when he focused on his bodily

movements. Later on he felt his surrounding environment and his body "*implanted seamlessly*" and he "*totally forgot about his body movements"*. Alice also felt a level of integrity of her body, her surrounding environment and 'Hearing the Hidden'. She felt her body and the practice "*formed an entirety*". Apart from an immersive experience with strong body awareness and attention, Mary and J were involved in 'Hearing the Hidden' because they were highly focused on the activity. Mary felt herself involved in the practice as she tried to think about "*what to do on this experiment, what can that what can this experiment make better or more friendly to use*". J was immersed in walking with 'Hearing the Hidden' as she was relying on the sensor, the sound and the graphics on the screen to explore the surroundings, particularly in the darkness. At that point she "*wasn't at any point aware of other noises in the room" and "particularly not thinking too deeply about where I was or what I was doing. It was sort of like "I'm just going to play with this light for a while"."*

5.4.2.6 How did the surroundings altered the sixth-sense experience?

When participants completed their walk in the light room, all of them indicated a preference of experiencing 'Hearing the Hidden' in the dark room. I reflected that this is because in the dark room they had a stronger curiosity, reliability and/or concentration on using the app. Alice thought 'Hearing the Hidden' in the dark gave her "*a stronger sensation trigger" as it was more mysterious and made her more focused. This stopped her from "being distracted by the things which has no connection with you in that minute*". Mary preferred walking in the dark because she had more expectation. In the bright room she would have *"no expectation"*, as she would "know where everything was". She also perceived that the ultrasonic hat and the phone (that she thought also helped in detecting the hidden objects) were "more sensitive in the dark room" as she had more intention to check the accuracy of detection when she was able to see the surrounding. Connie and Dean preferred the darkness as it allowed them to have a stronger first-person full-body experience. Connie would focus more on her own bodily sensations in the darkness while she partly focused on other things apart from the sound and visuals generated by 'Hearing the Hidden'. Though she intended to explore more about how the surroundings interacted with 'Hearing the Hidden' in the bright room. Dean stated that in the dark room "*it was totally me"*. He thought the light might have reduced his attention on listening to the sound by showing him everything existed in the room.

Apart from the differences in awareness of the environment and attention to the body movements, J discussed that her different experiences were due to the different levels of

details unveiled in the surroundings. She noted that in the light room she was able to see much more details and objects that she did not notice when it was dark. This resulted in a different immersive experience with the lights off. She relied more on the sound and graphics generated by the app in the dark, where she was immersed in the environment created by the app. When the light was on, she could see *"the terrain of the room more clearly"* as well as (kind of like) *"mapping your way around"*. It was immersive as "you are particularly not thinking too deeply about where I was or what I was doing". While it is different from the immersive experience in the dark as J was focused on perceiving the surroundings she could see apart from the 'surroundings' formed by the app.

5.5 Discussion of 'Hearing the Hidden'

In this chapter, I presented 'Hearing the Hidden', an extension of 'Ambient Walk' to explore adding a 'sixth-sense' from users' bodily interactions with the external environment. Such experiences were augmented by sonification and visualisation designs according to the distance data (which represents user walking activities in relation to the layout of the space). A Thematic Analysis of participants' engagement with 'Hearing the Hidden' suggested that bodily interactions with the external environment would enrich the self-reflection in forming a holistic somaesthetic experience. In the context of walking in the dark, participants engaged with ludic experiences that encouraged them to explore 'Hearing the Hidden' in multiple ways, either following the sound or creatively 'improvise' the sound by moving their body deliberately. They commented that 'Hearing the Hidden' has made them more aware of their body movements by knowing their relative locations towards nearby objects while listening to the distances. Such experiences are different from the 'inward-focus' bodily experiences that people obtain high-level concentration on their in-body activities. In 'Hearing the Hidden', bodily activities were mirrored by the detected distances towards the external environment, while people feel and reflect on their moods and steps during their communication with the venue they were in. Participants also engaged different affective experiences when they used 'Hearing the Hidden' in the bright room. Their feelings differ due to the awareness of the layout of the room and their attention to their walking with the app. A more detailed discussion of the significance of the research findings with 'Hearing the Hidden' and 'Ambient Walk' is included in Chapter 6.

Chapter 6: Discussion

In this research I conducted two design practices, ‘Ambient Walk’ and ‘Hearing the Hidden’, to explore using biophysical sensing technology to cultivate somaesthetic experiences. The two practices used data sonification and visualisation to reflect bodily experiences by seeing and hearing one’s own body and seeing and hearing the body in relation to the changing surroundings. ‘Ambient Walk’ provided a soundscape of body movements, which sonified participants’ breathing and walking to create an augmented sound layer for cultivating their perceptions of walking. The design artefact of ‘Ambient Walk’ used minimal sensory devices – a mobile phone with microphone, and a headphone for better listening experiences, to foster users’ perceptions of their own bodily movements during walking meditation.

The findings from the ‘Ambient Walk’ studies unveiled that users have encountered non-mindfulness experiences, while these experiences extended users’ perception of their breathing and walking activities. These findings of novel somaesthetic experiences contributed in re-accenting the research purpose into crafting a ‘sixth sense’ to cultivate somaesthetic experiences, which then informed the making of ‘Hearing the Hidden’. ‘Hearing the Hidden’ explored bodily experiences from another perspective – bodily experiences towards the perception of the surroundings in relation to one’s bodily movements. By mimicking echolocation and the Doppler effect for short distances, ‘Hearing the Hidden’ enhanced participants’ awareness of the dynamic changes of the layout of the place they were in in relation to their body movements at walking. They were able to determine their body position (such as whether they were closer to the right side of the room or the left) and bodily movements (such as which direction that were they moving in, and whether they were closer to an object or further away from it). In this chapter, I am going to discuss the general findings of the two case studies in three aspects: the connection and re-accentation between ‘Ambient Walk’ and ‘Hearing the Hidden’ in body-centred design; the use of ‘provotypes’(Boer & Donovan 2012) in designing for somaesthetic experiences; the whole research process of ‘making design theories’ by providing design artefacts as the ‘facts’ representing the concept of somaesthetic design with mindfulness practice and with ‘adding a sixth-sense’ experience.

6.1 Exploring Somaesthetics Design from Mindfulness and Adding a 'Sixth-Sense'

In body-centred design such as somaesthetic design, researchers have explored using data sonification and visualisation to foster inward-focused experiences (Höök et al. 2015). In Thich Nhat Hanh's (2010) mindfulness practices, awareness of 'the surrounding world' is as important as our self-awareness of our bodily experiences. Many Somaesthetics Design case studies provided a 'private space' for the practitioners to ensure they have a safe and non-interruptive environment to prompt inward-focused reflection of their own body movements (e.g. the dark chamber for *Sonic Cradle (Vidyarthi et al., 2012)* and the lamp for *Breathing Light (Stahl et al., 2016)).* Somaesthetic experiences are not only about the appreciation of bodily experiences within our physical body, but also the experiences with our body's interaction with the surrounding world (Shusterman 2002). Human echolocation is an example which echolocation practitioners not only 'hear' the quality of other objects, but also reflect their perceptions and intentions from their echolocating experiences (Flanagin et al. 2017), which is also a kind of somaesthetic experience (as a type of bodily perceptual experience). Therefore, in this research, I not only studied how individuals feel and perceive their own body during walking meditation with 'Ambient Walk', but also developed understanding about how body perceptions and feelings are influenced by the surrounding world in 'Hearing the Hidden'. Both 'Ambient Walk' and 'Hearing the Hidden' study findings unfolded new area of exploration: cultivating somaesthetic experiences with Ambient Walk by 'adding a sixth sense', then inspired the making of 'Hearing the Hidden'.

In designing 'Ambient Walk', I focused on creating a stronger in-body experience by strengthening participants' awareness of their body – awareness of what is going on within their body and how their body feels. At its demonstration at the Interactions Gallery, I observed how audiences used 'Ambient Walk', noting their comments regarding how they understood the sonification in relation to walking and how they perceive their body movements during this practice. Most participants commented that they had a relaxing, calming and enjoyable experience with 'Ambient Walk' in general. Some noted that while using 'Ambient Walk', they had a deeper realisation of their breathing and walking pace via the sonification layer, which brought their attention away from other thoughts that may distract them from the practice. To observe the use of 'Ambient Walk' in everyday walking, I invited four participants – two mindfulness professionals and two practitioners with a few experience with body-centred practices – to use it and document their experiences for a week.

The two mindfulness professionals practised ‘Ambient Walk’ within their own mindfulness practices, including body scans and slow walks. Both of them noted that ‘Ambient Walk’ fostered their inward-focused experience towards their body sensations, movements and feelings, taking them away from their distracting thoughts. The other two participants used ‘Ambient Walk’ on their way to work and/or wandering around town at a normal pace. They noted higher awareness of their bodily movements and feelings towards the practice, but such concentrated exploration took their attention away from what was going on outside their physical body, including essential information to be aware of during walking.

As discussed in Chapter 4, ‘Ambient Walk’ was initially designed with mindfulness practice, *walking meditation*, to alter users’ somaesthetic experiences in everyday walking. With the visualisation and sonification according to the breathing and walking data, participants of ‘Ambient Walk’ have obtained higher focus and higher awareness of their breathing and walking rhythms. Comparing to *Sonic Cradle* (Vidyarthi et al., 2012) which allowed users to obtain mindfulness experiences by listening and observing the soundscape reflecting their breathing, ‘Ambient Walk’ took similar approach by creating generative soundscape that reflecting users’ breathing and walking activities. The differences between ‘Ambient Walk’ and *Sonic Cradle* (Vidyarthi et al., 2012) was that ‘Ambient Walk’ did not create a boundary of space or to reinforce *Media Immersion* (Vidyarthi et al., 2012) by ‘blocking out’ the interactions from the surroundings (e.g. environmental noise at the place of practice or interactions from other participants). The kind of somaesthetic experiences users engaged with ‘Ambient Walk’ were not only mindfulness experiences like in *Sonic Cradle* (Vidyarthi et al., 2012). ‘Ambient Walk’ was also different from *Soma Mat* and *Breathing Light* (Stahl et al., 2016) as the app did not adapt body-centered practices that creating unfamiliar bodily experiences e.g. *Feldenkrais* and *Alexander Technique*. Instead, ‘Ambient Walk’ was inspired by a mindfulness practice that cultivates our bodily experiences in everyday activities i.e. the Walking Meditation (Thich Nhat Hanh, 2006). At the Interactions Gallery and the empirical user study, participants have actively explored how their body activities may affect the visualisation or sonification of ‘Ambient Walk’. These active explorations were not mindfulness experiences as they involves subjective interpretations and decisions to alter the visual or sound effects of ‘Ambient Walk’. While we review these experiences from the perspective of engaging somaesthetic experiences by extending users’ perceptions of their body, ‘Ambient Walk’ extended the participants’ perception of their breathing and walking activities that users might not be aware of in everyday walking experiences. Moreover,

participants at both Interactions Gallery and empirical user study highlighted their experiences with bodily interactions with the surrounding environment had extended their perceptions and awareness of their body activities while practicing everyday walking. The extended somaesthetic experiences inspired me to investigate designing for somaesthetic experiences by enhancing user perceptions of their body interactions with the surroundings. Taking inspiration from Svanaes and Solheim (2016)'s *Wag your Tails and Flap your Ears* and Yvonne Rogers' research group's E-Sense projects (see Bird et al., 2008 and 2009), my research has then been re-accented to designing for somaesthetic experiences by 'adding a sixth-sense'. While Svanaes and Solheim (2016) created mechanical body parts to extend performers' perception of the body, my design practice did not create an 'extra body part' to let performers engage with unfamiliar body activities (e.g. wagging a tail). Instead, I used minimal extra device (i.e. the mobile phone app and wearable devices such as hats) with animated data visualisation and sonification to 'add a sixth sense'—hear the bodily interactions with the surroundings that users do not usually see. My design practice also did not create a virtual interactive activity like *Feel the Force* (Bird et al., 2008) or *Low-Fi Skin Vision* (Bird et al., 2009). Instead, I crafted the 'sixth sense' experience by interacting with real objects i.e. a normal indoor setting with walls and obstacles.

I designed 'Hearing the Hidden' to cultivate users' somaesthetic experience by 'adding a sixth-sense'. 'Hearing the Hidden' is different from binaural sound experiments that bring people's attention to the locations of the sound source. It is designed to cultivate users' attention to their bodily movements in relation to the change of the layout of the space, represented by the sonification of the changing distances to the objects. During the user experiment of 'Hearing the Hidden', participants not only obtained a deeper focus on listening to the nearby objects, but also a higher awareness of which direction they were walking in, what changed in their bodily movements based on the changing sound, and even where they would go to avoid hitting an obstacle. Some participants felt anxious and wanted to get away from an object when they heard a sound, while others were curious about the sound, which encouraged them to get closer to the objects. Participants started their exploration by focusing on understanding the layout of the space, while later on they became more focused on how they felt about their encounters with any detected objects, even creatively improvising their movements to explore the sound-movement relationship of 'Hearing the Hidden'. In this case, 'Hearing the Hidden' prompted these participants' somaesthetic experiences, in terms of their awareness of their bodily experiences interacting with the surrounding world.

6.2 Making ‘Provotypes’ to Unveil Novel Somaesthetic Experiences

In HCI design community, McCarthy and Wright (2015) proposed Experience-Centred Design as a design approach covering ‘design for experiences’ (including HCI design to prompt particular user experiences e.g. entertainment) and ‘design with experiences’ (e.g. participant/community-involved design that takes user experiences as collective design source). How do we find out the design that would expose and prompt somaesthetic experiences an individual encountered while interacting with the design artifacts? Interaction designers shall understand possible somaesthetic experiences users may engage and expose the differences (even conflicts) occurred in individual contexts. This information could be obtained throughout user’s engagement with the proposed design, which is regarded as a ‘provotype’ (Boer & Donovan 2012) (i.e. the provocative prototypes to make the designers know ‘where to draw the line’) that provokes user experiences in real time to inform further designs.

In this research I created two provotypes, ‘Ambient Walk’ and ‘Hearing the Hidden’, to prompt potential somaesthetic experiences. The two provotypes play a crucial role in the design process as, on the one hand, they provide users with a tangible design ‘fact’ to illustrate how the combination of digital art, body-centred practice and biophysical tracking technology would work in practice to prompt somaesthetic experiences. On the other hand, users’ engagement with these provotypes has provided me with first-hand information about the bodily experiences they encountered and their actions towards the sound and visual feedback. This information is not available in design theories or a designer’s own knowledge, but can only be obtained through users’ interactions with the provotypes. When I designed ‘Ambient Walk’, I took my own experience with walking meditation, different biophysical sensing devices and versions of data sonifications/visualisations. While I designed ‘Hearing the Hidden’, I referred to my walking with music and echolocating in the darkness as the design source, alongside the concepts and existing practices that inspired my design. However, I was uncertain about what somaesthetic experiences ‘Ambient Walk’ or ‘Hearing the Hidden’ would prompt for other users. The provotypes helped me in finding out the somaesthetic experiences that other users would encounter.

In this research, the provotypes have also contributed in ‘making design theories’ (Redström, 2017) by providing design ‘facts’ that represent the concepts of using digital art in HCI design for somaesthetic experiences by adapting everyday mindfulness practice (in the case of this

research, walking meditation) and 'adding a sixth sense'. Redström (2017) specified three pathways to make design theories: using conceptual findings (usually in the form of combination or fluid terms) to articulate existing design issues; specifying definitions of complex or obscure concepts that represented by the design practice; and combine the articulated definitions into a 'design program'. In this research, 'Ambient Walk' and 'Hearing the Hidden' were created as design 'facts'—where 'Ambient Walk' represent the initial design space with HCI design for somaesthetic experiences with body-centered practices i.e. walking meditation and 'Hearing the Hidden' were presented as design 'fact' of designing for somaesthetic experiences by 'adding a sixth sense'. The transition between 'Ambient Walk' and 'Hearing the Hidden' can be seen as an unfolding process that the concepts from the former informed the latter. The whole research process can be described as Fig 6.2 below:

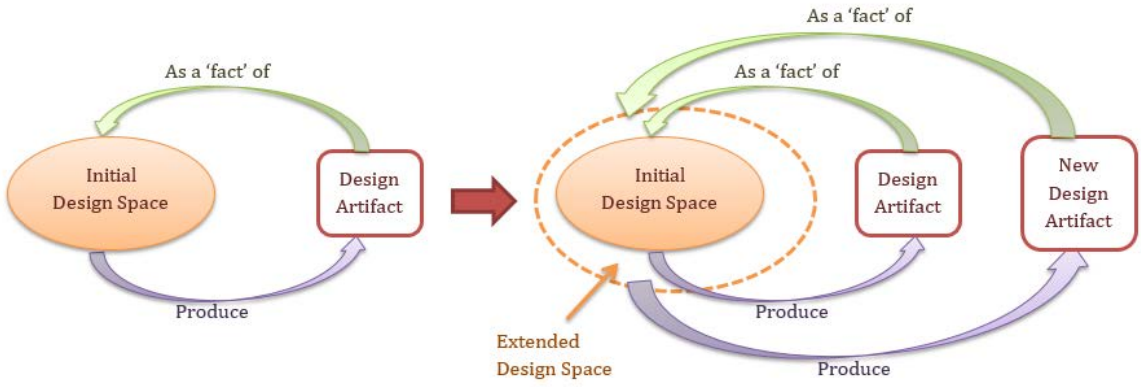

Fig 6.2 The role of 'Provotypes' (the design artefacts) referring to Redström (2017)'s 'bucket' model in making design theory: design artefact as a 'fact' to present the theory 'made' by design practices, 'provotypes' were created to provoke the transitioning, re-accenting or unfolding process in my research.

6.3 Data Visualisation and Sonification in Body-Centred Interaction: How do they bring engaging experiences

As there were already a number of technology innovations in Affective Computing that provided highly accurate applications to understand our bodily experiences, what are the benefits of bringing digital art into HCI designs for bodily experiences? As described by Khut (2006), *"Somatic bodywork methods involve a momentary surrender of these response patterns, during which time the body-worker introduces a flood of unfamiliar sensations and movements to stimulate new or long forgotten sensorimotor experiences designed to provide the client with a more up-to date sense of themselves and how they can be in a given situation (i.e. work, sport, home, dance, etc.)."* (cited in Höök et al. 2015, page 3132) In our daily

walking, we may have neglected a lot of experiences that might be interesting. We may only think about the direction and destination we are heading to and missed a lot of interesting experiences on the way. Thich Nhat Hanh's mindfulness practices were proposed to bring our attention back to discover the interesting experiences in the current moment. However, it is less engaging when practitioners had to remember the instructions instead of 'feel and react to' the instructions that enhance their somaesthetic experience.

Digital art methods, such as data sonification and visualisation, have successfully provided an augmented reality that actively engages users. Digital art integrated into 'Ambient Walk' and 'Hearing the Hidden' not only provided live representations of information on our bodily activities, but also provided responsive feedback to provoke users' aesthetic appreciation of their body activities and potential perceptual/emotional/behavioural changes during their practice. In 'Ambient Walk', the sonification provided users with an extra layer to bring their attention towards their practice. By listening to the beats and waves, users would actively adjust their breathing and walking towards the rhythm, in the way that people follow the rhythm of music while walking or dancing. The visualisation on the screen also respond to users' body activities so that they can perceive the intensity of their breathing, walking and emotional arousal during walking with 'Ambient Walk'. The sonification and visualisation also provided a semi-immersive space to allow for better concentration on 'Ambient Walk'. One participant who took part in the week-long study said that without the sound layer provided by 'Ambient Walk', they would feel more likely to be distracted by other thoughts. In 'Hearing the Hidden', the sonification and visualisation not only provided an immersive environment, but also informed users about how their bodily movements altered in relation to the change of the layout of surrounding objects. Compared to the direct presentation of biophysical data in health apps (e.g. Buddify 2 (21awake 2014b)), the visualisation and sonification layers prompted users' curiosity to discover the space, detect objects nearby, and inform them of their responses to the existence of the objects. Digital art is included to form a responsive feedback mechanism to actively engage users in 'Ambient Walk' and 'Hearing the Hidden', to grab users' attention to their bodily experiences and to provide a medium to prompt enjoyable experiences.

Chapter 7: Conclusion

The doctoral research presented in this thesis explored the use of digital art and interactive technology to alter people's somaesthetic experience in everyday practices such as walking. The aim of this research was to find out 1) whether we could generate HCI design that alter our somaesthetic experiences using data sonification and visualisation to reflect our body activities and bodily interactions with the surroundings; 2) how did we apply novel practical methods (in this research context, making 'provotypes') in creating designs that represent a combination of research areas in the context of designing for somaesthetic experiences with walking meditation and 'adding a sixth sense' in everyday walking; and 3) how did we provide an example of 'making design theories' by creating initial design space, generate the first 'provotype' that led to the unfolding of initial design space with findings of novel user experiences, the making of second 'provotype' with expanded design space and contributed to the research areas related to HCI design for somaesthetic experiences. The research practice began with setting up an initial design space formed by interactive data visualisation and sonification, HCI design for somaesthetic experience and body-centred practices such as mindfulness practice. The exploration began by a critical review of *Affective Computing* to clarify the position of this research as in the extended territory of 'designing for bodily experiences that affect and being affected by the body and body's interactions with the surroundings'. Then I reviewed relevant theories and practices in digital art, HCI and body-centred practices to provide a theoretical framework and design context. With inspiration from existing practices for bodily experiences (such as art installations with biophysical feedback), I conducted two case studies of the design practices, 'Ambient Walk' and 'Hearing the Hidden', to explore using digital art and HCI design to foster somaesthetic experiences in walking meditation and to bring a 'sixth-sense' experience. This final chapter summarises the relationship between the key theories and practices from the relevant fields, draws upon the findings from the case studies, and articulates their contributions to somaesthetic design inquiry in HCI. In the process, I address each of my research questions, and identify potential future research directions in the maturing discourse on body-centred interaction design within the HCI field.

7.1 Addressing Research Objectives and Context for Design

This research explored the use of data visualisation and sonification, biophysical sensing technology and body-centred practices (such as mindfulness and deep listening) to alter human bodily experiences in everyday walking. The exploration was initiated with a different perspective on how technology could understand bodily experiences, seeing technology's potential to provoke somaesthetic experiences via creative visualisation and sonification of users' body activities. The conceptual framework, design exploration and evidence gathering in this thesis responded to the HCI design inquiry to explore technology augmentation of bodily experiences. I now turn to revisit my research objectives derived from the research questions outlined in Chapter 1.

1. I explored if individual users could alter their walking experiences by enhancing their somaesthetic experiences, in ways that could be provoked or augmented by digital-art-integrated interaction design, and by designing novel pieces that combine data visualisation, data sonification and body-centred practices.
2. I generated design artefacts as design examples to bring up discussions about using digital art, biophysical sensing technology, body-centred practices or 'adding a sixth-sense' to provoke novel somaesthetic experiences. These cases were grounded in a review of extant work in this design space.
3. I investigated 'making design theory' (Redstrom, 2017) drawn upon the *Research through Design* approach and exploring how to cultivate and reflect on somaesthetic experiences, and to contribute these reflections on HCI design for embodied qualities. I also considered how to generate new knowledge – new research understanding – through a creative design practice.

7.2 Contributions to the HCI Design Community

This research explored the intersection of digital art, HCI design for somaesthetic experiences and body-centred practices, which is an under-explored area in the HCI design community. It proposed the conceptual framework within multiple disciplines such as somaesthetic appreciation design, digital art practices and body-centred practices. In detail, this research has contributed to the HCI design community in the following aspects:

1. This research has provided practical case studies of exploring using biophysical data-driven feedback mechanism to cultivate somaesthetic experiences (e.g. sixth-sense experiences) in walking.

Somaesthetic Design practices (Höök et al., 2016) enhance bodily experiences through interaction with smart objects (i.e. things with the technology that understand our body movements, sensations, etc.). There is opportunity to develop understanding in this design space through the contribution of case studies in differing contexts. Through my doctoral research, I contribute 'Ambient Walk' and 'Hearing the Hidden' as two practical case studies that explore users' bodily sensations, perception and engagement with somaesthetic experiences during body-centred practices, such as walking meditation and echolocation. The design processes of 'Ambient Walk' and 'Hearing the Hidden' were distinct from traditional design processes (in which designers identify requirements, make prototypes and evaluate). Instead, the design process was experience-driven and experience-centred – it began with my own practices of walking meditation and echolocation, my initial making of the applications to engage users, my observation of user reactions and investigation of users' provoked body sensations, perceptions and intuition during walking with 'Ambient Walk and 'Hearing the Hidden'. The findings from the Ambient Walk exploration revealed how visualisation/ sonification of body activities (breathing and walking) enhanced users' awareness of their aesthetic perceptions of their body activities such as breathing and walking, together with the provoked actions (e.g. walk faster or slower when the rhythm changed, become highly focused when the sound becomes louder). Findings from 'Hearing the Hidden' illuminated how users engaged with strong bodily experiences while perceiving the surrounding space interacting with their body; it's study further considered how these experiences are relevant for developing Somaesthetic Design.

2. This research provided design examples that explore somaesthetics design from two perspectives: from *inward-focused* experiences and body-with-surroundings experiences (i.e. somaesthetic experiences occurred during the body's interaction with the surrounding world, or the process of how the body affects and is affected by the surrounding world).

Previous HCI research for bodily experiences took bodily experiences as awareness, sensation and perception occurred within the physical body of the individual —such as body kinetics (the phenomenon of body movements) and kinaesthetics (the appreciation of body movements) (Loke et al. 2012; Loke & Robertson 2013). To cultivate high attention to in-

body experiences, many extant somaesthetic design practices emphasise the importance of blocking out the interactions from outside of our body (Höök et al., 2016). However, when I interviewed the participants after their 'Ambient Walk' practices, many of them noted the importance of awareness of the interactions with their surroundings. For example, it is important to know our own breathing intensity, but it is also important to know nearby vehicles' speeds so we can see how close we are to them. The second case, 'Hearing the Hidden', illustrated how we could use HCI design to enhance our experiences during bodily interactions with the surroundings which reflect our body sensations and perceptions. The two case studies complement each other to form an extended design space of HCI design for somaesthetic experiences. Moreover, this research extended the set of mindfulness practices by not only encouraging high immersion of inward bodily experiences but also augmenting the connections between the body and real-world interactions (interactions with the surroundings of our body). Especially, 'Hearing the Hidden' encouraged users to listen to their interactions with the place (i.e. the distance and direction changes occurring during their practice) to become more aware of their body. Both 'Ambient Walk' and 'Hearing the Hidden' resituated their practitioners from being aware of their own body only to being aware of the body in relation to the surrounding environment.

3. This research provided an example of 'making design theories' (Redström, 2017) by making design artefacts as 'facts' to represent complex concepts of designing for somaesthetic experiences, in particular, the transitional, unfolding process from adapting mindfulness practice to adding a sixth sense.

In HCI design for bodily experiences, designers have explored using affective technology, data recording and user reporting for self-reflection (Sundström et al. 2005). In creative art practices, many artists explored using digital art to provoke certain bodily experiences in art installations and performances (for example, synchronised breathing (Schiphorst 2005) and touch (Schiphorst 2009a)) with specific environmental settings, devices and chorographic dancing expertise (Feltham & Loke 2014). Referring to Redström (2017)'s 'making design theories', these design practices could be some 'facts' representing the complex concepts they aimed to weave together. This research was inspired by existing art and design practices aiming to enhance body awareness and body affective experiences, and weaving together relevant concepts from each area to form the initial design space. Building upon a literature review (in Chapter 2), I positioned my design practice in exploring the expanded territory of the initial design space with HCI design for

somaesthetic experiences, body-centered practices such as mindfulness and deep listening and digital art methods such as data visualisation and sonification. My first practical project of this research, 'Ambient Walk', was created in the context of using a mindfulness practice—the walking meditation—to cultivate somaesthetic experiences in everyday walking. Drawn upon the findings of 'Ambient Walk', I discovered user experiences that was not related, or counterprove the kind of experience that the designer wanted to achieve.

The connection between 'Ambient Walk' and 'Hearing the Hidden' was made distinct from previous *Research through Design* studies from design studios, such as the collection of *The Curious Home* (Beaver et al., 2007) and *Somaesthetic Appreciation Design (Höök et al., 2016). The Curious Home* involves many makings exploring completely different design contexts to create a particular kind of experience--the *Homo Luden* experiences. Similarly, *Somaesthetic Appreciation Design* explored different body-centered practices (e.g. *Feldenkrais* and sitting meditation), sensor technology to detect body activities (e.g. breathing belt and touch-based sensors) and generative mechanism (e.g. sonification, graphic visualisation and movements of physical objects). The individual projects are not inspired from the findings of other projects. In this research, 'Hearing the Hidden' took inspiration from the findings of 'Ambient Walk' and looking into other concepts that were not covered in the design space of 'Ambient Walk'. The design artefacts, 'Ambient Walk' and 'Hearing the Hidden', present my proposal for a design inquiry into somaesthetics and the cultivation of sixth-sense experiences. The design and evaluation processes of 'Ambient Walk' and 'Hearing the Hidden' illustrated how data visualisation/sonification, HCI design and body-centred practices collaborated with each other to produce the findings of this research.

7.3 Future Work

The initial designs and prototyping for 'Ambient Walk' and 'Hearing the Hidden' were based on my own experiences with walking meditation, walking in the darkness and walking with ambient sound. When I practised walking meditation, I focused on listening to the rhythm from the surroundings – everything created a regular soundscape, and every irregular sound or object became part of the soundscape. However, such a soundscape is usually ignored in our

normal walking. Recently, a number of designers have proposed the practice of 'urban soundscape design' for which they carefully plan the materials and tools to filter unpleasant noise, or to raise people's awareness of the existing regularity within the perceived irregular noise. I was inspired by this idea and conducted initial design practices to produce the soundscapes of bodily activities within the body and interactions with surroundings to raise people's body awareness throughout everyday activities.

This research was my initial exploration of combining sound composition and visualisation design (as digital art methods) into HCI design for body-centered practices. The design artefacts, 'Ambient Walk' and 'Hearing the Hidden', integrated digital art as a way to cultivate somaesthetic experiences in body-centred practices such as mindfulness; the artefacts used minimal visualisation and sonification as a metaphoric presentation of the data. According to participants' feedback on 'Ambient Walk' and 'Hearing the Hidden', the visual/sonic representation was clear to some while vague for others. The variation of sound and visual design was also limited as the two design artefacts were not bespoke to individual preferences. The making of 'Ambient Walk' and 'Hearing the Hidden' illustrated how to 'make design theories' with consecutive design projects, which one inspired the re-accentation of the other.

As a set of linked studies, this doctoral research provides an impetus for design explorations of body-centred practices with interactive digital art as an augmented reality layer to cultivate somaesthetic experiences. Future work in extending the variety of sound/visual designs may include the exploration of various sound and/or visual designs to prompt intimate affective experiences (e.g. more complex sonification design) and bespoke art-integrated somaesthetic design for individual preferences/scenarios. This research has been informed by Experience-Centred Design (McCarthy & Wright, 2017) to conduct HCI design for personal experiences especially bodily experiences. In designing the artefacts ('Ambient Walk' and 'Hearing the Hidden'), I collected my design resources from philosophical concepts, existing design practices and my own experiences (as an autobiographical resource) to inspire my initial prototypes. I invited professionals in data visualisation and sonification to produce collaborative work for the second design iteration of 'Ambient Walk'. I invited users to evaluate the prototypes after I made them, but I did not invite users at the initial idea-making stage. Future explorations could involve users in the design and making process to further explore the somaesthetic design space through cocreative practice with end users.

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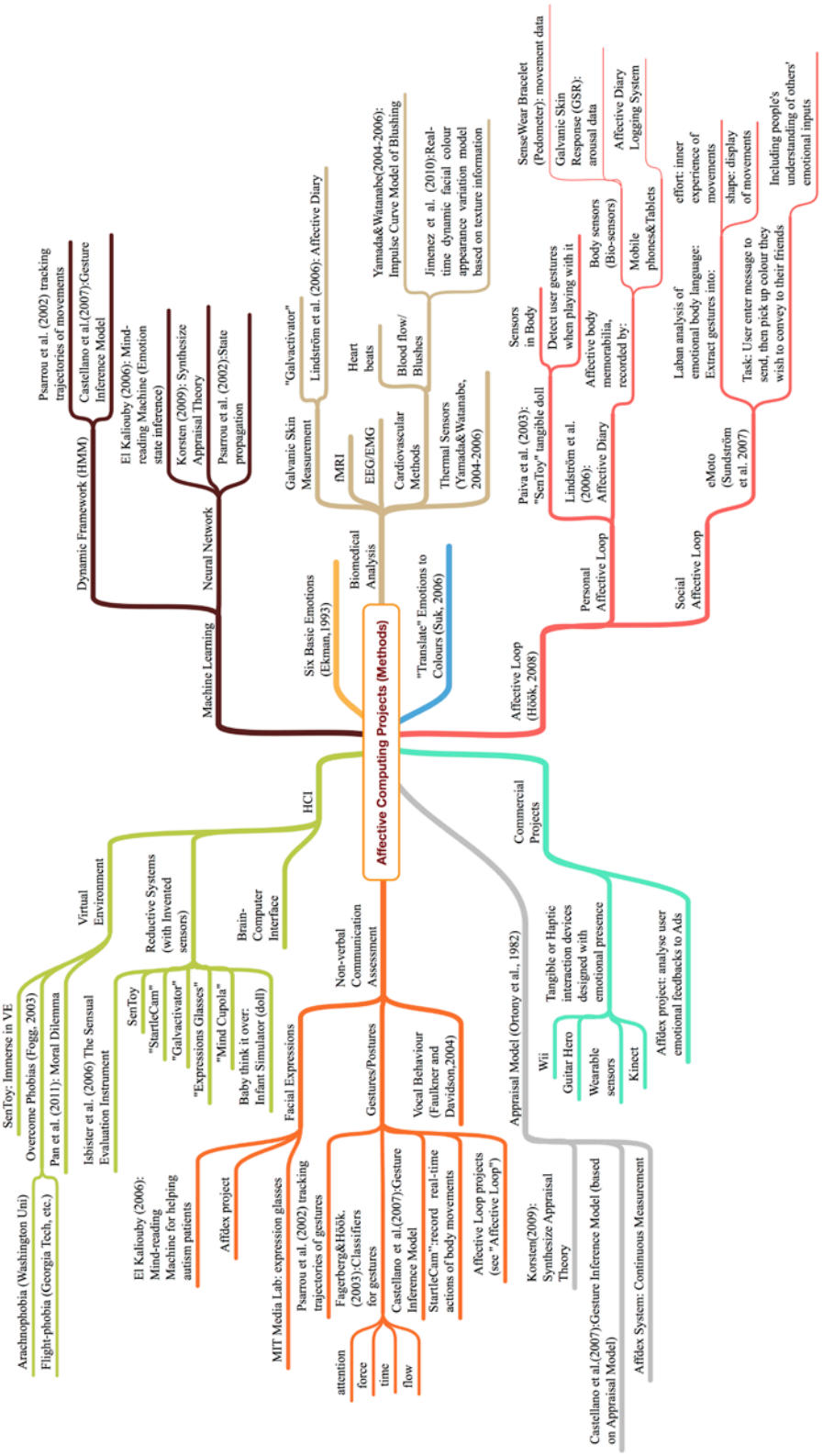
Appendix A: Pictorials

Overview of Affective Computing: Example Practices



Ambient Walk: Visual Brainstorming

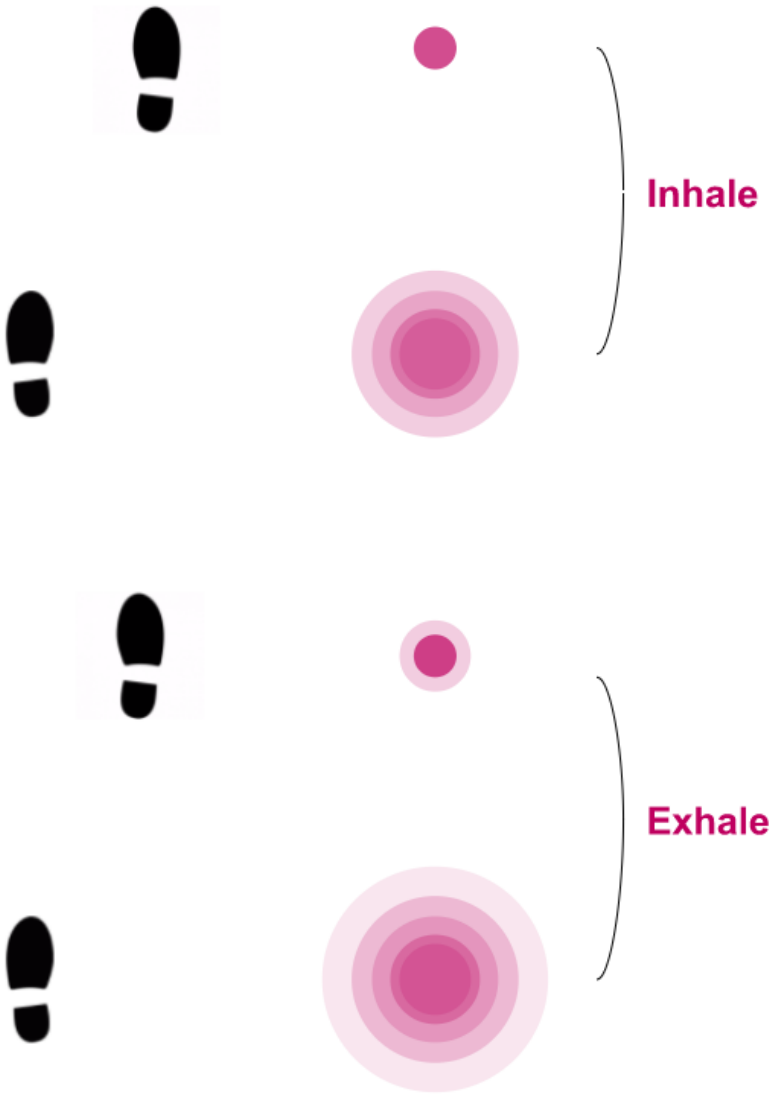
Animated Circle:
Momental Intensity

Waveform Blocks:
Continuous Intensity

Dots: Pace/Rhythm

Particles:
Dynamic Movements;
Intensity

Ambient Walk: User Interaction

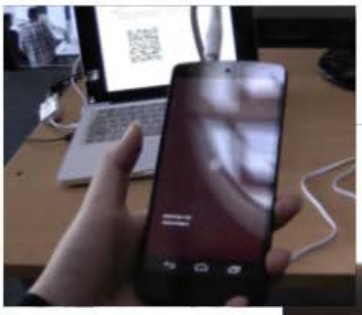


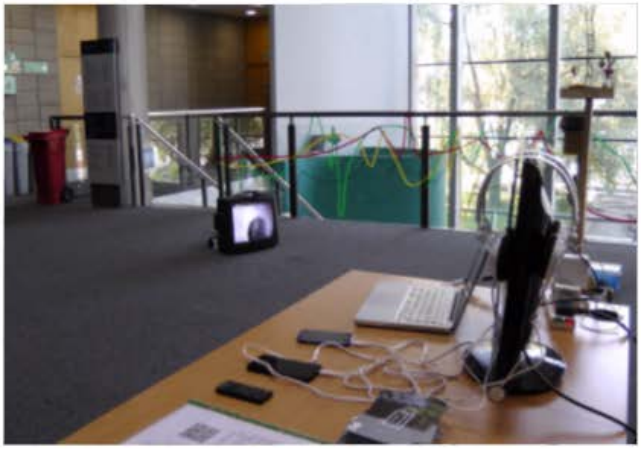
Walking Pace (is harmonic to) Breathing Period

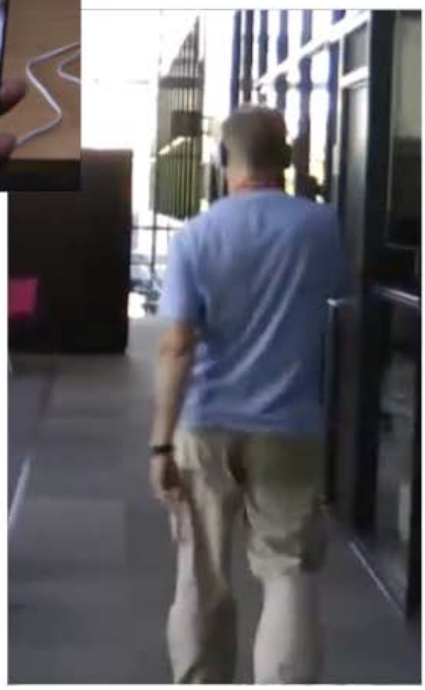
Ambient Walk: at Interactions Gallery

The venue and the exhibition desk

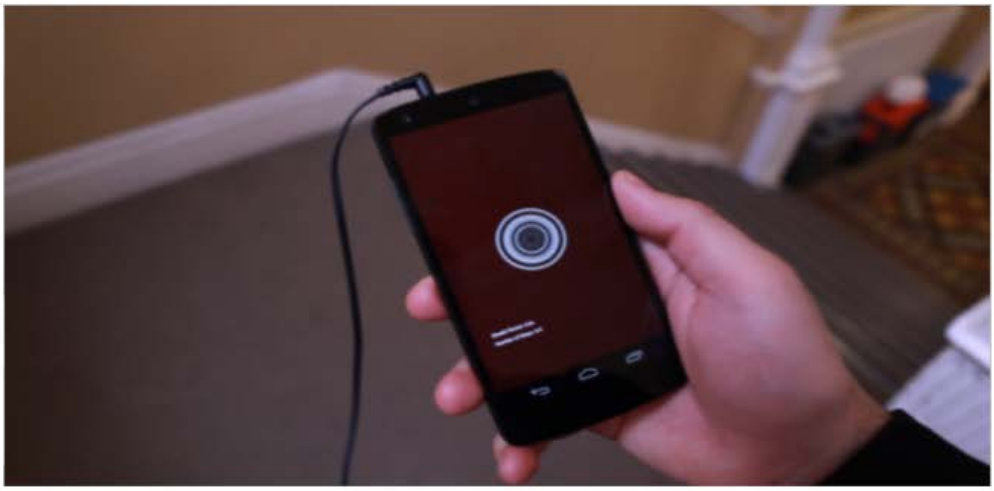
The visualisation of 'Ambient Walk'

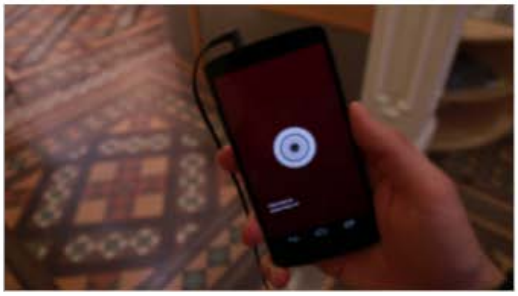






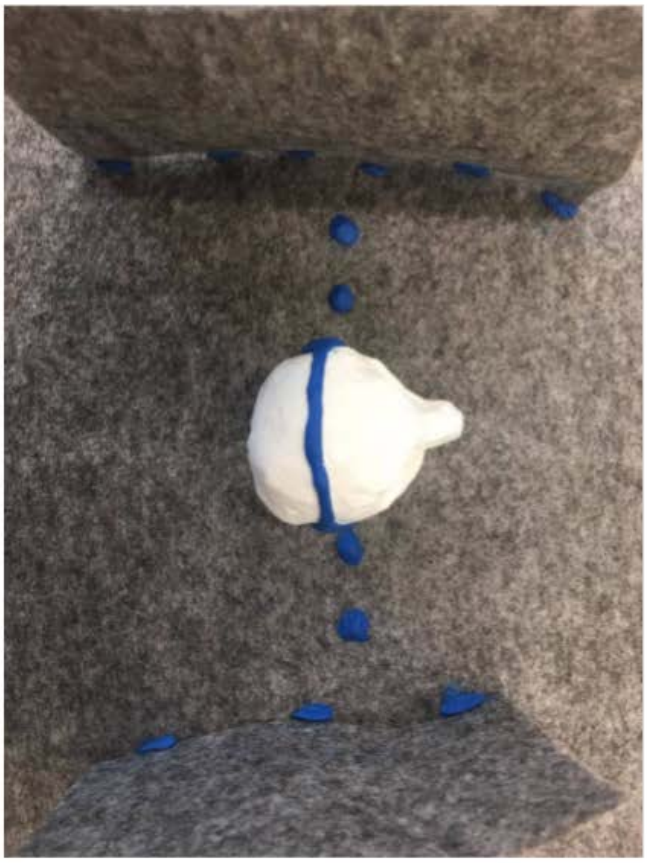
Ambient Walk: In Use





The app captures breathing and walking pace well for both indoor and outdoor walking

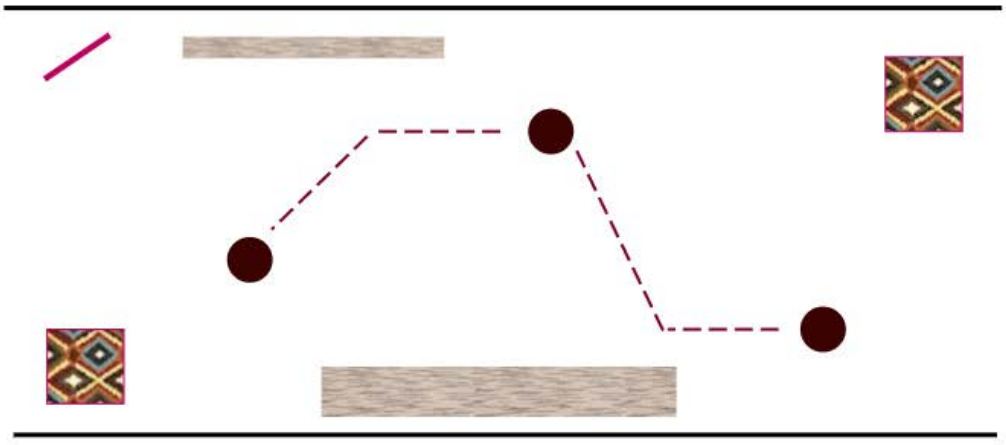
Hearing the Hidden: Scenario/Interaction



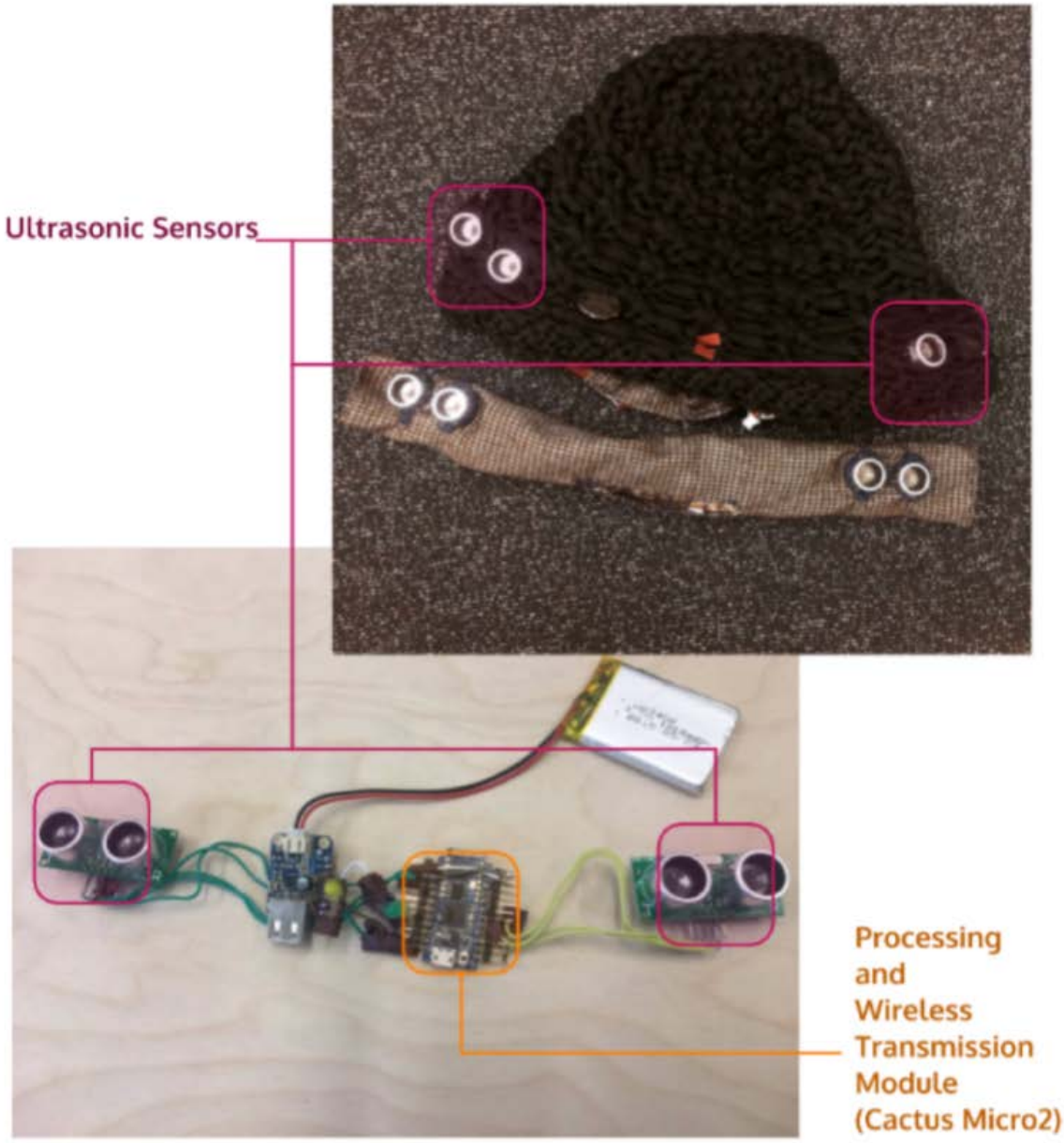
1. User hears the sound, knowing he/she was walking towards an object.

2. He/she either comes closer to the object with curiousity, or goes away from it with alert.

3. The sound helps users reflect on their walking activities in relation to the changing layout of the space.



Hearing the Hidden: Design of the Ultrasonic Hat



Appendix B: Ethical Approval and Consent forms for User Study

B1: Newcastle University Ethical Approval

As part of its assurances and compliance processes the University ensures that all appropriate projects, including student research and consultancy projects, undergo appropriate ethical review before commencement. This form is used identify high risk projects which may require further full ethical review. Additional guidance can be found at: http://www.ncl.ac.uk/res/research/ethics_governance/ethics/index.htm

Note that the project title on the form was the title submitted at the time of ethical approval. The title has been changed over my PhD due to the changes of research scope and contents.

SECTION 1: Applicant Details

Name of Researcher (Applicant):	Sixian Chen
Faculty & School:	SACS
Email Address:	**s.chen17@newcastle.ac.uk**
Contact Address:	**Culture Lab, King's Road, Newcastle upon Tyne**
Telephone Number:	**+44 7581312377**

SECTION 2: Project Details

Project Title:	**Synthesis of Emotional Intelligence with Investigation of Human Continuous Behaviour, Emotion and Aesthetic Perception.**	
Has ethical approval to cover this proposal already been obtained?	**YES** ☐	**NO** ☒
If **YES**, please confirm:	**Approving Body:**	
	Reference Number:	
	Date of Approval:	
WILL ANYONE BE ACTING AS SPONSOR UNDER THE NHS RESEARCH GOVERNANCE FRAMEWORK FOR HEALTH AND SOCIAL CARE?	**YES** ☐	**NO** ☒
	IF 'YES' PLEASE ENTER THE NAME OF THE SPONSOR:	
DO YOU HAVE A NUTH REFERENCE?	**YES** ☐	**NO** ☒
	IF 'YES' PLEASE ENTER THE REFERENCE:	

IF YOU ALREADY HAVE APPROVAL THEN YOU DO NOT NEED TO COMPLETE THE REST OF THE FORM. PLEASE GO DIRECTLY TO THE DECLARATION IN SECTION 8.

SECTION 3: ANIMALS

	YES	NO

"Does the research involve the use or observation of 'protected animals' as defined in the Animals (Scientific Procedures) Act 1986 (i.e. live vertebrates excluding man but including embryos after half way through gestation and cephalopods)?"	☐	☒

*IF YOU ANSWERED **YES** TO SECTION 3, YOU WILL NEED TO SUBMIT AN APPLICATION TO THE UNIVERSITY ETHICAL REVIEW COMMITTEE, BASED IN THE FACULTY OF MEDICAL SCIENCES.*
PLEASE CONTINUE WITH THE REST OF THE FORM.

SECTION 4: NHS, HEALTH & SOCIAL CARE: FACILITIES, STAFF & PATIENTS

	YES	NO
"Will the study involve participants recruited by virtue of being service users, their dependents, their carers or human tissues or the use of NHS & Health / Social Care Facilities or otherwise require REC approval? (If you are unsure please tick 'Yes and complete the sub-questions)	☐	☒

*IF YOU ANSWERED **NO** TO THIS QUESTION, PLEASE GO TO SECTION 5*
*IF YOU ANSWERED **YES** TO THIS QUESTION, PLEASE COMPLETE THE REST OF THE QUESTIONS BELOW.*

WILL THE STUDY INVOLVE ANY OF THE FOLLOWING?	YES	NO
a. PATIENTS AND USERS OF THE NHS?	☐	☒
b. RELATIVES OR CARERS OF PATIENTS AND USERS OF THE NHS?	☐	☒
c. FOETAL MATERIAL, HUMAN TISSUES OR IVF INVOLVING NHS PATIENTS?	☐	☒
d. THE RECENTLY DEAD IN NHS PREMISES?	☐	☒
e. REQUIRES THE USE OF, OR ACCESS TO NHS PREMISES OF FACILITIES (LABS, CLINICS) OR THE STUDY IS A CLINICAL TRIAL?	☐	☒
f. PARTICIPANTS AGED 16 OR OVER WHO ARE UNABLE TO GIVE INFORMED CONSENT E.G. PEOPLE WITH LEARNING DISABILITIES. FOR A FULL LIST SEE THE MENTAL CAPACITY ACT 2005?	☐	☒
g. Human participants (users) in a social care setting within the UK and N. Ireland?	☐	☒
h. Intergenerational studies in social care, involving adults, children, or families as research participants?	☐	☒
i. Or will the study come under the remit of GAFREC?	☐	☒

*IF YOU ANSWERED **YES** TO ANY OF SECTION 4, YOU NEED TO SUBMIT AN APPLICATION FOR FULL ETHICAL REVIEW TO THE APPROPRIATE EXTERNAL HEALTH AUTHORITY ETHICS COMMITTEE THROUGH THE NATIONAL RESEARCH ETHICS SERVICE (NRES) – SEE HTTP://WWW.HRA.NHS.UK/HRA/ FOR THE PROCESS.*
PLEASE CONTINUE WITH THE REST OF THE FORM.

SECTION 5: HUMAN PARTICIPANTS IN A NON-CLINICAL SETTING

	YES	NO
DOES THE RESEARCH INVOLVE HUMAN PARTICIPANTS E.G. USE OF QUESTIONNAIRES, FOCUS GROUPS, OBSERVATION OR SURVEYS? (IF YOU ARE UNSURE PLEASE TICK 'YES' AND COMPLETE THE SUB-QUESTIONS)	☒	☐

*IF YOU ANSWERED **NO** TO THIS QUESTION, PLEASE GO TO SECTION 6*
*IF YOU ANSWERED **YES** TO THIS QUESTION, PLEASE COMPLETE THE REST OF THE QUESTIONS BELOW.*

	YES	NO
a. DOES THE STUDY INVOLVE OTHER VULNERABLE GROUPS; AS DEFINED IN SECTION 59 OF THE SAFEGUARDING VULNERABLE ADULTS ACT 2006 AS THOSE WHO ARE RELATIVELY OR ABSOLUTELY INCAPABLE OF PROTECTING THEIR OWN INTERESTS, OR THOSE IN UNEQUAL RELATIONSHIPS E.G. YOUR OWN STUDENTS?	☐	☒
b. WILL THE STUDY REQUIRE THE CO-OPERATION OF A GATEKEEPER FOR INITIAL ACCESS TO THE GROUPS OR INDIVIDUALS TO BE RECRUITED E.G. STUDENTS AT SCHOOL, MEMBERS OF A SELF-HELP GROUP, OR RESIDENTS OF A NURSING HOME?	☐	☒
c. WILL IT BE NECESSARY FOR PARTICIPANTS TO TAKE PART IN THE STUDY WITHOUT THEIR KNOWLEDGE AND CONSENT E.G. COVERT OBSERVATION OF PEOPLE IN NON-PUBLIC PLACES?	☐	☒
d. WILL THIS STUDY INVOLVE DELIBERATELY MISLEADING PARTICIPANTS IN ANY WAY?	☐	☒
e. WILL THE STUDY INVOLVE DISCUSSION OF SENSITIVE TOPICS E.G. SEXUAL ACTIVITY OR DRUG USE?	☐	☒
f. ARE ANY DRUGS, PLACEBOS OR OTHER SUBSTANCES (E.G. FOOD SUBSTANCES, VITAMINS) TO BE ADMINISTERED TO THE STUDY PARTICIPANTS OR WILL THE STUDY INVOLVE INVASIVE, INTRUSIVE OR POTENTIALLY HARMFUL PROCEDURES OF ANY KIND?*	☐	☒
g. WILL BLOOD OR TISSUE SAMPLES BE OBTAINED FROM SUBJECTS?*	☐	☒
h. IS PAIN OR MORE THAN MILD DISCOMFORT LIKELY TO RESULT FROM THE STUDY?	☐	☒
i. COULD THE STUDY INDUCE PSYCHOLOGICAL STRESS OR ANXIETY OR CAUSE HARM OR NEGATIVE CONSEQUENCES BEYOND THE RISKS ENCOUNTERED IN NORMAL LIFE?	☐	☒
j. WILL THE STUDY INVOLVE PROLONGED OR REPETITIVE TESTING?	☐	☒
k. WILL FINANCIAL INDUCEMENTS (OTHER THAN REASONABLE EXPENSES AND COMPENSATION FOR TIME) BE OFFERED TO PARTICIPANTS?	☐	☒

* **PLEASE NOTE**: DEPENDING ON THE DETAILS OF THIS PROJECT, THIS MAY REQUIRE NHS APPROVAL. YOU WILL BE GIVEN FURTHER CLARIFICATION IF THE PROJECT IS AWARDED. YOU ARE ALSO ADVISED TO CONSULT THE JRO POLICY REGARDING THE PARTICIPATION OF VOLUNTEERS IN RESEARCH PROJECTS.

*IF YOU HAVE ANSWERED **YES** TO ANY OF QUESTIONS IN SECTION 5: YOU WILL NEED TO DESCRIBE MORE FULLY HOW YOU PLAN TO DEAL WITH THE ETHICAL ISSUES RAISED BY YOUR RESEARCH BY COMPLETING THE FULL ETHICAL APPROVAL APPLICATION FORM (AFTER YOUR PROJECT HAS SUCCESSFULLY BEEN AWARDED).*
PLEASE CONTINUE WITH THE REST OF THE FORM.

SECTION 6: DATA

	YES	NO
DOES THE RESEARCH INVOLVE THE USAGE OR TRANSFER OF SENSITIVE PERSONAL DATA AS DEFINED AS BY THE DATA PROTECTION ACT 1998 OR DATA GOVERNED BY STATUTE SUCH AS THE OFFICIAL SECRETS ACT, COMMERCIAL CONTRACT OR BY CONVENTION E.G. CLIENT CONFIDENTIALITY? (IF YOU ARE UNSURE PLEASE TICK 'YES' AND COMPLETE THE SUB-QUESTIONS)	☐	☒

*IF YOU ANSWERED **NO** TO THIS QUESTION, PLEASE GO TO SECTION 7*
*IF YOU ANSWERED **YES** TO THIS QUESTION, PLEASE COMPLETE THE REST OF THE QUESTIONS BELOW.*

	YES	NO
a. Will the study involve the sharing of sensitive data outside the European Economic Area?	☐	☒
b. WILL THE STUDY INVOLVE THE COLLECTION OR ANALYSIS OF SENSITIVE DATA WHICH WILL BE IDENTIFIABLE WITHIN THE PROJECT OUTPUTS AND COULD POTENTIALLY CAUSE HARM?	☐	☒
c. Will the study involve the collection or analysis of personal data without explicit consent?	☐	☒
d. Will the study involve the collection or analysis of information covered by the Official Secrets Act, Terrorism Act, commercial contract or license?	☐	☒

*IF YOU HAVE ANSWERED **YES** TO ANY OF QUESTIONS IN SECTION 6: YOU WILL NEED TO DESCRIBE MORE FULLY HOW YOU PLAN TO DEAL WITH THE ETHICAL ISSUES RAISED BY YOUR RESEARCH BY COMPLETING THE FULL ETHICAL APPROVAL APPLICATION FORM (AFTER YOUR PROJECT HAS SUCCESSFULLY BEEN AWARDED).*
PLEASE CONTINUE WITH THE REST OF THE FORM.

SECTION 7: ENVIRONMENT

	YES	NO
Will the study cause direct or indirect damage to the environment or emissions outside permissible levels or be conducted in an area of special scientific or cultural interest? (If you are unsure please tick 'Yes' and complete the sub-questions)	☐	☒

*IF YOU ANSWERED **NO** TO THIS QUESTION, PLEASE GO TO SECTION 8*
*IF YOU ANSWERED **YES** TO THIS QUESTION, PLEASE COMPLETE THE REST OF THE QUESTIONS BELOW.*

	YES	NO

a. Is the research expected to lead to emissions to land, air or water ***above*** the permissible level according to UK regulations (or local regulations in the case of non-UK research)?	☐	☐
b. Is the research expected to lead to a detrimental effect to the landscape or cultural heritage, including artefacts?	☐	☐
c. Is it expected that the research might cause harm through environmental fieldwork such as sampling or monitoring a site?	☐	☐
d. Will the research be conducted in an environmentally sensitive area or area of special scientific interest?	☐	☐

*IF YOU HAVE ANSWERED **YES** TO ANY OF QUESTIONS IN SECTION 7: YOU WILL NEED TO DESCRIBE MORE FULLY HOW YOU PLAN TO DEAL WITH THE ETHICAL ISSUES RAISED BY YOUR RESEARCH BY COMPLETING THE FULL ETHICAL APPROVAL APPLICATION FORM (AFTER YOUR PROJECT HAS SUCCESSFULLY BEEN AWARDED).*
PLEASE CONTINUE WITH THE REST OF THE FORM.

SECTION 8: INTERNATIONAL PROJECTS

	YES	NO
Will the research be conducted outside of the European Economic Area (EEA) or will it involve international collaborators outside the EEA?	☐	☒

*"If you have answered **YES** to the question in Section 8 you will need to describe more fully how you plan to deal with the ethical issues raised by your research by completing the Full Ethical Approval application form (after your project has successfully been awarded)."*
PLEASE CONTINUE TO THE DECLARATION.

SECTION 9: DECLARATION

I CERTIFY THAT THE INFORMATION CONTAINED IN THIS APPLICATION IS ACCURATE AND THAT THE RESEARCH WILL BE UNDERTAKEN IN LINE WITH ALL APPROPRIATE LOCAL STANDARDS AND REGULATIONS.	
NAME OF PRINCIPAL INVESTIGATOR:	SIXIAN CHEN
SIGNED:	陳思賢
DATE:	13/12/2013

If you have any queries about this or any other ethical issue, please contact your Faculty Ethics Coordinator or appropriate Grants and Contracts team**.**

For office use only:

Date received in G&C:	Requires full approval: YES/NO

NB We need to ascertain how applicants will obtain informed consent and maintain confidentiality of data – this is covered on the full form, but we also need to know this is being addressed for projects that do not hit a trigger which requires completion of the full form.

B2: Online Consent Form for ‘Ambient Walk’ User Study

'Ambient Walk' User Feedback

You are invited to participate in this user study. Before you decide your participation, it is important for you to understand how the study will be conducted and what you are expected to do. Please take your time to read the following text carefully and contact s.chen17@ncl.ac.uk for any questions if there is anything that needs further explanation.

The Purpose of the Study
This user study aims to investigate potential user experiences towards the engagement with mindful walking instructed by the mobile application ‘ambient walk’, which uses data songification as an intervention that provides meditative experience in our daily activities. The study includes user interaction with a mobile application (app) that generates ambient tones according to breathing and walking.

Expected User Interaction
You will use the app on a daily basis for one week, and give feedback on your experiences of use.
Your participation will involve testing the app on an android phone that can be provided (or alternatively the app may be installed on your own phone). You are invited to use headphones for the optimal sonic experience.
To use the app, you hold the phone in hand, focus on breathing slowly and evenly into the microphone while walking as usual, either following the generative beats or at your own pace.

Potential Benefits of Participation
By participating in this study, you will get a new experience of sound-based meditation that is easy to practice every day. And potentially, you may benefit from using the app as an alternative method for relaxation.

Potential Risk and Withdrawal of the Study
You may find listening to ambient tones uncomfortable and distractive during the user study. In this case, you can withdraw your participation at any point by informing the study contact.

Data Collection and Use
The breathing and walking data will be logged to a .txt file on the SD card of the phone. All the data logged by the app will only been kept for quantitative analysis and reference. Participants are asked to provide email feedback about your experience of the app every day during the testing week. All data collected (from data logging and user feedback) in this user study will only be used for data analysis e and publication. Participants’ feedbacks will be confidential and be stored anonymously.

If you have questions about this project, a research-related problem or need assistance during the study, you may contact Sixian Chen by email: s.chen17@ncl.ac.uk. Thank you very much for your interest of taking part in this user study.

By clicking “I agree” below you are indicating that you have read and understood this consent form and agree to participate in this research study. Please print a copy of this page for your records.

Your name: *

Faith Miller

Do you agree to participate in this study? *

Please read the above information section and choose one of them

- (●) I agree
- ( ) I do not agree

Ambient Walk and Mindfulness

Have you practiced/heard of mindfulness or meditation? *

- (●) Yes
- ( ) No

'Ambient Walk' User Feedback

You are invited to participate in this user study. Before you decide your participation, it is important for you to understand how the study will be conducted and what you are expected to do. Please take your time to read the following text carefully and contact s.chen17@ncl.ac.uk for any questions if there is anything that needs further explanation.

The Purpose of the Study
This user study aims to investigate potential user experiences towards the engagement with mindful walking instructed by the mobile application 'ambient walk', which uses data songification as an intervention that provides meditative experience in our daily activities. The study includes user interaction with a mobile application (app) that generates ambient tones according to breathing and walking.

Expected User Interaction
You will use the app on a daily basis for one week, and give feedback on your experiences of use.
Your participation will involve testing the app on an android phone that can be provided (or alternatively the app may be installed on your own phone). You are invited to use headphones for the optimal sonic experience.
To use the app, you hold the phone in hand, focus on breathing slowly and evenly into the microphone while walking as usual, either following the generative beats or at your own pace.

Potential Benefits of Participation
By participating in this study, you will get a new experience of sound-based meditation that is easy to practice every day. And potentially, you may benefit from using the app as an alternative method for relaxation.

Potential Risk and Withdrawal of the Study
You may find listening to ambient tones uncomfortable and distractive during the user study. In this case, you can withdraw your participation at any point by informing the study contact.

Data Collection and Use
The breathing and walking data will be logged to a .txt file on the SD card of the phone. All the data logged by the app will only been kept for quantitative analysis and reference. Participants are asked to provide email feedback about your experience of the app every day during the testing week. All data collected (from data logging and user feedback) in this user study will only be used for data analysis e and publication. Participants' feedbacks will be confidential and be stored anonymously.

If you have questions about this project, a research-related problem or need assistance during the study, you may contact Sixian Chen by email: s.chen17@ncl.ac.uk. Thank you very much for your interest of taking part in this user study.

By clicking "I agree" below you are indicating that you have read and understood this consent form and agree to participate in this research study. Please print a copy of this page for your records.

Your name: *

jlia fitzgeald

Do you agree to participate in this study? *
Please read the above information section and choose one of them

- (●) I agree
- ( ) I do not agree

Ambient Walk and Mindfulness

Have you practiced/heard of mindfulness or meditation? *

- (●) Yes
- ( ) No

Tell us your experiences/moments that you fully engage with things happening around you at the moment you use 'ambient walk' *
Have you had a moment that you fully immersed in the sonic feedback created by the app, observing what's happening around you and neglecting things happened in another moment? If yes, give us some examples when you were involved in a moment like this.

waking with th dog in the park awre of the positioning of my feet on the ground
walkin up and down he hall fousing on my beathing

'Ambient Walk' User Feedback

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Data Collection and Use
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If you have questions about this project, a research-related problem or need assistance during the study, you may contact Sixian Chen by email: s.chen17@ncl.ac.uk. Thank you very much for your interest of taking part in this user study.

By clicking "I agree" below you are indicating that you have read and understood this consent form and agree to participate in this research study. Please print a copy of this page for your records.

Your name: *

Chengcheng Wu

'Ambient Walk' User Feedback

You are invited to participate in this user study. Before you decide your participation, it is important for you to understand how the study will be conducted and what you are expected to do. Please take your time to read the following text carefully and contact s.chen17@ncl.ac.uk for any questions if there is anything that needs further explanation.

The Purpose of the Study
This user study aims to investigate potential user experiences towards the engagement with mindful walking instructed by the mobile application 'ambient walk', which uses data songification as an intervention that provides meditative experience in our daily activities. The study includes user interaction with a mobile application (app) that generates ambient tones according to breathing and walking.

Expected User Interaction
You will use the app on a daily basis for one week, and give feedback on your experiences of use.
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Potential Benefits of Participation
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If you have questions about this project, a research-related problem or need assistance during the study, you may contact Sixian Chen by email: s.chen17@ncl.ac.uk. Thank you very much for your interest of taking part in this user study.

By clicking "I agree" below you are indicating that you have read and understood this consent form and agree to participate in this research study. Please print a copy of this page for your records.

Your name: *

Qi Zhang

B3: Consent Forms for 'Hearing the Hidden' User study

Newcastle University

Consent Form for 'Hearing the Hidden' User Study

Name: Fang Qi Pseudo Name: Alice Clay Email: q.fang1@newcastle.ac.uk

I, the undersigned, confirm that (please tick box as appropriate):

1.	I have read and understood the information about the project, as provided in the Information Sheet.	☑
2.	I have been given the opportunity to ask questions about the project and my participation.	☑
3.	I voluntarily agree to participate in the project.	☑
4.	I understand I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	☑
5.	The procedures regarding confidentiality have been clearly explained (e.g. use of names, pseudonyms, anonymisation of data, etc.) to me.	☑
6.	If applicable, separate terms of consent for interviews, audio, video or other forms of data collection have been explained and provided to me.	☑
7.	The use of the data in research, publications, sharing and archiving has been explained to me.	☑
8.	I understand that other researchers will have access to this data only if they agree to preserve the confidentiality of the data and if they agree to the terms I have specified in this form.	☑
9.	Select only **one** of the following: • I give permit to the researcher to use my data (images/audio/video recordings) and understand what I have said or written as part of this study will be used in reports, publications and other research outputs so that anything I have contributed to this project can be recognised. • I do not want my images/audio/video recordings to be included in future publication (in which case we will choose images without your front face).	☑ ☐
10.	I, along with the Researcher, agree to sign and date this informed consent form.	☑

Participant:

Fang Qi — Name of Participant

Signature

13.07.2017 — Date

Researcher:

SIXIAN CHEN — Name of Researcher

Signature

13.07.2017 — Date

Project Title: Research Study Example
Main Contact: Dr Example (example@ncl.ac.uk)

Consent Form for 'Hearing the Hidden' User Study

Newcastle University

Name: Jessica Crosby Pseudo Name: J Email: j.m.crosby1@ncl.ac.uk

I, the undersigned, confirm that (please tick box as appropriate):

1.	I have read and understood the information about the project, as provided in the Information Sheet.	☑
2.	I have been given the opportunity to ask questions about the project and my participation.	☑
3.	I voluntarily agree to participate in the project.	☑
4.	I understand I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	☑
5.	The procedures regarding confidentiality have been clearly explained (e.g. use of names, pseudonyms, anonymisation of data, etc.) to me.	☑
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10.	I, along with the Researcher, agree to sign and date this informed consent form.	☑

Participant:

Jessica Crosby — Name of Participant

J Crosby — Signature

17/7/17 — Date

Researcher: SIXIAN CHEN 陈思贤 17/07/2017.

Project Title: [redacted]

Main Contact: [redacted] s.chen17@ncl.ac.uk.

Consent Form for 'Hearing the Hidden' User Study

Newcastle University

Name: Dean Saraf Pseudo Name: Dean Email: dean@deansaraf.co.uk

I, the undersigned, confirm that (please tick box as appropriate):

1.	I have read and understood the information about the project, as provided in the Information Sheet.	☑
2.	I have been given the opportunity to ask questions about the project and my participation.	☑
3.	I voluntarily agree to participate in the project.	☑
4.	I understand I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	☑
5.	The procedures regarding confidentiality have been clearly explained (e.g. use of names, pseudonyms, anonymisation of data, etc.) to me.	☑
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9.	Select only **one** of the following: • I give permit to the researcher to use my data (images/audio/video recordings) and understand what I have said or written as part of this study will be used in reports, publications and other research outputs so that anything I have contributed to this project can be recognised. • I do not want my images/audio/video recordings to be included in future publication (in which case we will choose images without your front face).	☑ ☐
10.	I, along with the Researcher, agree to sign and date this informed consent form.	☑

Participant:

Dean Saraf — Name of Participant

Signature

17/07/2017 — Date

Researcher: SIXIAN CHEN 陈思贤 17/07/2017

Project Title: [redacted]

Main Contact: [redacted] s.chen17@ncl.ac.uk

Consent Form for 'Hearing the Hidden' User Study

Newcastle University

Name: CHENGCHENG WU Pseudo Name: Connie Email: C.WU4@ncl.ac.uk

I, the undersigned, confirm that (please tick box as appropriate):

1.	I have read and understood the information about the project, as provided in the Information Sheet.	☒
2.	I have been given the opportunity to ask questions about the project and my participation.	☒
3.	I voluntarily agree to participate in the project.	☒
4.	I understand I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	☒
5.	The procedures regarding confidentiality have been clearly explained (e.g. use of names, pseudonyms, anonymisation of data, etc.) to me.	☒
6.	If applicable, separate terms of consent for interviews, audio, video or other forms of data collection have been explained and provided to me.	☒
7.	The use of the data in research, publications, sharing and archiving has been explained to me.	☒
8.	I understand that other researchers will have access to this data only if they agree to preserve the confidentiality of the data and if they agree to the terms I have specified in this form.	☒
9.	Select only **one** of the following: • I give permit to the researcher to use my data (images/audio/video recordings) and understand what I have said or written as part of this study will be used in reports, publications and other research outputs so that anything I have contributed to this project can be recognised. • I do not want my images/audio/video recordings to be included in future publication (in which case we will choose images without your front face).	☐ ☒
10.	I, along with the Researcher, agree to sign and date this informed consent form.	☒

Participant:

CHENGCHENG WU C.Wu 17/07/2017

Name of Participant Signature Date

Researcher: SIXIAN CHEN 陈思贤 17/07/2017

Project Title: [redacted]

Main Contact: [redacted]

Consent Form for 'Hearing the Hidden' User Study

Newcastle University

Name: Wu Chia Shing Pseudo Name: Mary Email: c.wu8@ncl.ac.uk

I, the undersigned, confirm that (please tick box as appropriate):

1.	I have read and understood the information about the project, as provided in the Information Sheet.	☑
2.	I have been given the opportunity to ask questions about the project and my participation.	☑
3.	I voluntarily agree to participate in the project.	☑
4.	I understand I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	☑
5.	The procedures regarding confidentiality have been clearly explained (e.g. use of names, pseudonyms, anonymisation of data, etc.) to me.	☑
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10.	I, along with the Researcher, agree to sign and date this informed consent form.	☑

Participant:

Wu Chia Shing — Name of Participant

Signature

18/07/2017 — Date

Researcher: SIXIAN CHEN 陈思贤 18/07/2017