Embodied interaction choreographies

Kinesthetic approach to intelligent enviroment design

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Tiivistelmä

Tutkimus tarkastelee vuorovaikutussuunnittelua koreografian käsitteen kautta. Koreografinen lähestymistapa tarkastelee teknologian kokonaisvaltaista ohjausvaikutusta käyttäjän liikkeeseen teknologian käyttötilanteessa. Koreografinen suunnitteluote korostaa liikkeen kokemuksen huomioimisen tärkeyttä vuorovaikutussuunnittelussa ja tarjoaa menetelmiä monitasoisen vuorovaikutusanalyysin toteuttamiseen. Kinestesian käsite, jolla tarkoitetaan liikkeen kokemista kehossa, nousee yhdeksi koreografisen lähestymistavan keskeisistä käsitteistä.

Sovellan koreografista menetelmää tulevaisuuden älykästä informaatio- ja kommunikaatioympäristöä kuvaavan vision tutkimiseen. Älykkäällä ympäristöllä viittaan kehityskulkuun, jossa jokapäiväisissä ympäristöissämme läsnä oleva teknologia verkottuu, kykenee keräämään ja jakamaan tietoa ympäristöstä ja käyttäjistä sekä mahdollistaa tiedon jalostuksen käyttäjän tarpeita palvelevalla tavalla. Aineistona on käytetty Microsoftin teknologiavisioita, joissa esitetyt kuvaukset älykkäistä ympäristöistä sekä esimerkit käyttäjän ja teknologian välisistä liikkeellisistä vuorovaikutuksista nousevat analyysin kohteeksi. Analyysissa keskitytään ensinnäkin käyttäjän toteuttamien mikroliikkeiden jatkumon kokemuksen analyysiin. Toiseksi analysoidaan yksilön kokemusta paikallisen tason koreografioissa. Tällä analyysitasolla huomiota kiinnitetään teknologista vuorovaikutusta laajemman vuorovaikutustapahtuman kontekstiin jolloin mm. sosiaaliset tapahtumat ja tilan vaikutus vuorovaikutukseen tulevat huomioiduksi. Analyysi toteutetaan tehtäväperusteisena ja analyysi käsittää kaksi toimintoa: tiedostojen jakaminen ja vastaanottaminen sekä datan ja visualisointien muokkaus.

Toteutin tutkimuksen nojaten fenomenologiseen metodologiaan, joka mahdollisti koreografioiden henkilökohtaisen omaksumisen tanssin eli tutkimuksen kohteena olevien vuorovaikutustapojen kehollisen harjoittamisen kautta. Teknologiavisioissa esitetyn liikemateriaalin perusteella jäsentyi koreografia, jonka tanssiminen mahdollisti liiketiedon sisäistämisen ja vuorovaikutusten kehollisesti koettujen ulottuvuuksien arvioinnin. Tutkimus osoitti koreografisen analyysin ja osittain tanssimalla toteutetun ruumiin hermeneuttisen lähestymistavan soveltuvan hyvin sovellettavaksi yhdessä älykästä ympäristöä käsittelevässä tapaustutkimuksessa. Tutkimuksen johtopäätöksenä koreografisen menetelmän ja vuorovaikutusten kehollisen harjoittamisen todetaan auttavan suunnittelijaa tilassa, ajassa ja liikkeessä tapahtuvien vuorovaikutusten jäsentämisessä, ja arvioimaan miten teknologisen järjestelmän suunnitteluratkaisut vaikuttavat käyttäjän kehoon ja liikkeeseen vuorovaikutustapahtumassa. Esitän 'tanssimista koreografisena käytäntönä' sovellettavaksi älykkäiden ympäristöjen käyttäjäkeskeisen suunnittelun menetelmänä.

Avainsanat vuorovaikutussuunnittelu, älykäs ympäristö, koreografinen menetelmä

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Abstract

Research investigates interaction design through application of the concept of choreography. Special attention is paid to assess what kind of influences technological designs have on the user's body and movements. Choreographic approach to interaction design emphasizes the felt experience of movement as content to interaction design and offers methods for conducting multi-level choreographic analysis. The concept of kinesthesia, which refers to the felt sensation of movement, is regarded as the foundational concept for both understanding and realizing the choreographic analysis.

Choreographic method is applied in studying a future vision of intelligent information and communication environments. Intelligent environment refers to development where objects in everyday environments become connected and form a communicating-actuating network that possess abilities to collect information on the environment and of its users, and enables processing of this information for serving the user's needs. The research data consists of two visions on intelligent environments in video format, introduced by Microsoft. Visions are analyzed through choreographic analysis with intention to investigate interactions between the user, the intelligent environment and the computer system. Micro level choreography analysis focuses on how the user experiences choreographies as movement continuums. Also local level choreographies that address the broader interaction context will be analyzed. Task-based analysis focuses on two functions, first, sending and fetching digital information and, second, real time re-modelling of data and visualizations.

Phenomenological methodology that enabled embodiment of the choreographies through dancing was applied in the analysis. Dancing aimed at internalizing the choreographies and enabled the analysis of felt sensation of movement. Key finding of the study is that choreographic analysis and hermeneutics of the body work well to be utilized in tandem in conducting a case study research on intelligent ICT environments. Dancing is considered as choreographic practice that provides understanding on the unfolding of interactions in space, time and movement. Furthermore, dancing integrates the designer's explicit technological information to the design context and highlights the kinesthetic dimension of interaction. Presented methods provide relevant support for defining technological systems in intelligent ICT environments that are grounded in the embodied experience of interaction. I suggest that 'dancing as choreographic practice' is to be applied in user-centered design of intelligent information and communication environments.

Keywords interaction design, intelligent environment, choreographic analysis

INTRODUCTION 8

1.1 The need for studying interaction choreography 9
1.2 Dance in studying interaction design. 1
1.3 The concept of choreography in studying interaction design. 11
1.4 Description of the case and research questions. 11

THEORY 14

2.1 Computer systems and embedded sensor networks for real-time sensing . . 15
2.2 Interfaces for choreographing human-computer interactions. 17
2.3 Kinesthetic foundation of subjective interactive experience 18
2.3.1 Haptic-tactile perception 19
2.3.2 Visual perception. 20

METHODS + DATA 22

3.1 Methodology – Phenomenology 23
3.1.1 Body and the experience of movement in kinesthetic dance research 23
3.1.2 Hermeneutics of the body 24
3.1.3 Constructing embodied understanding on intelligent ICT-environments. 24
3.1.4 Tacit and explicit knowledge 26
3.2 Research strategy – Case study 27
3.2.1 Challenge of the case study 27
3.2.2 Beginning from the research theory 27
3.2.3 Collecting data for the first case. 28
3.2.4 Reformulating the research theory. 29
3.2.5 Trials for choreographic analysis 30
3.2.6 Dancing the case study 31
3.2.7 Generalizability of the case study results 31
3.2.8. Shortcomings of the data and research 32
3.3 Method – Choreographic analysis 33
3.3.1 Introduction to choreographic analysis 33
3.3.2 Spatial scales and scope of the choreographic analysis 34
3.4 Data – Industrial choreography and productivity future vision 35
3.5 Organization of the data – Scenarios and examples. 37

ANALYSIS 38

4.1 Sharing and fetching digital content 39
4.1.1 Micro-choreographies for sharing and fetching digital content. 39
4.1.2 Local level choreographies for sharing and fetching digital content. 44
4.2 Choreographies for modelling data and visualizations. 46
4.2.1 Micro choreographies for modelling data and visualizations. 47
4.2.2 Local level choreographies for modelling data and visualizations 51

FINDINGS 54

5.1 Emphasis on user-centred choreographies. 55
5.2 Form factors 55
5.3 User-driven choreographies and networked resources 57
5.4 Users freedom in choreographic performance. .57
5.5 Continuums of visual-haptic focuses. 58
5.6 Dancing as a choreographic practice 59
5.7 Interaction choreography in intelligent ICT environments abstracted. 60

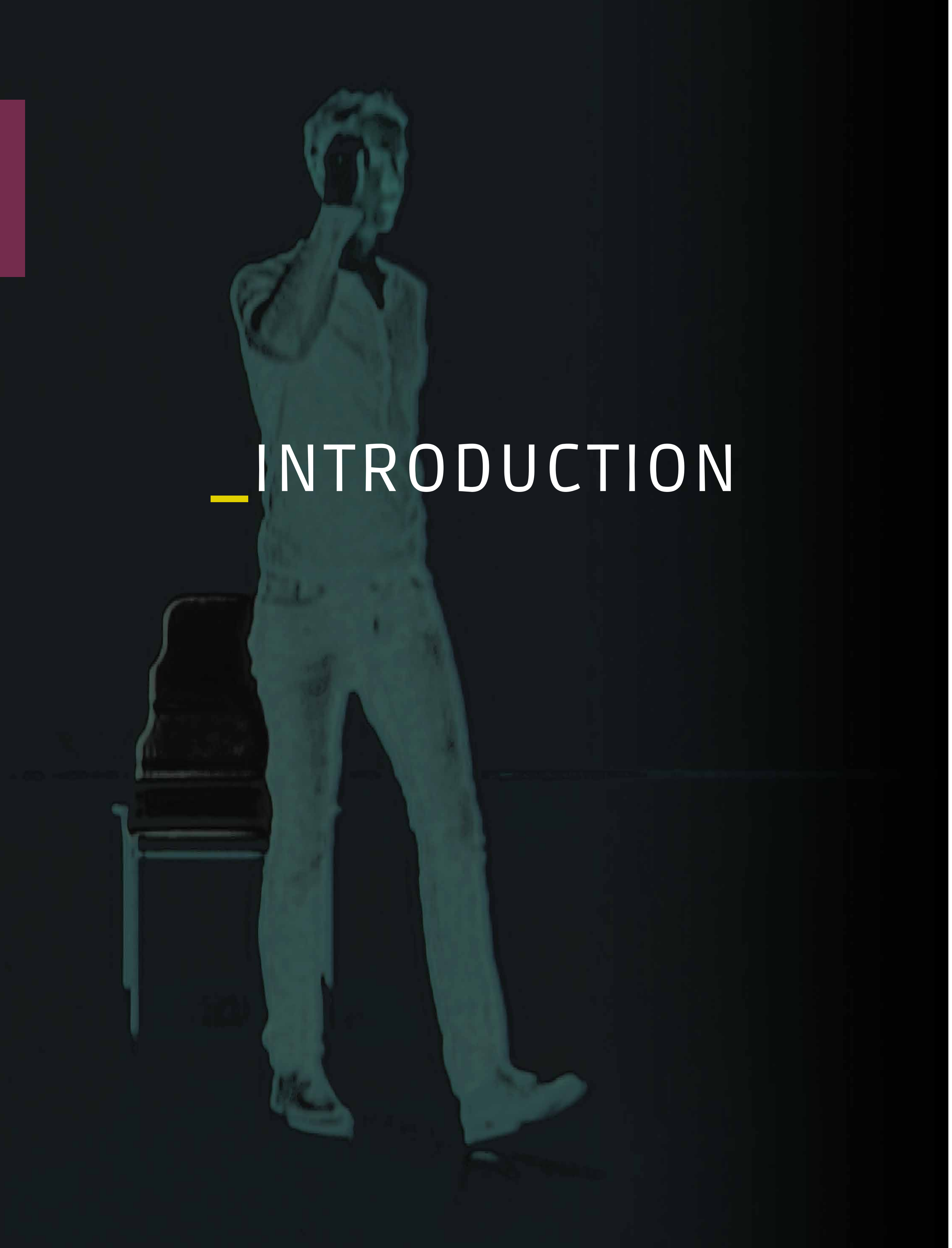
CONCLUSIONS 62

5.7 CONCLUSIONS. 62

DISCUSSION 66

5.8 DISCUSSION 66

References. 68
APPENDIX I: ANALYSIS TABLES 70



_INTRODUCTION

1.1 The need for studying interaction choreography

Socially assimilated behavioural norms and structures impose invisible control on how people move in everyday spaces. Pre-designed movement vocabularies and principles related to technology use further strengthen the control on the user's body and movement. Consequently, the users have settled for using very restricted, both socially and technologically pre-defined, repertoires of movements in their daily interactions. This shows clearly in institutionalized contexts such as schools and workplaces. Repression of the inherent kinesthetic creativity of the human being can be seen detrimental both to cognitive and physical faculties (compare Parviainen, Tuuri and Pirhonen, 2013). I claim that there is a societal paradox between the ideals of constant learning and innovation and the reality that restricts the practices of thinking through the body. As a response to this major issue I argue that the interaction designers' ability to allow the users to move constructively in creative processes is at least enriched by if not totally dependent on the development of choreographic design methodologies and their careful contextual application.

The computing paradigm is moving from single-device-centred personal communication scenarios to interconnection of everyday objects that leads to emergence of the intelligent environment (Gubbi, et. al., 2013, p.1645–1646). An increasing number of sensors, processing and communications embedded in everyday objects provide the capability to produce "deeper understanding of the internal and external worlds encountered by humans" (Swan, 2012, p.217). These developments will gradually enable major improvements in the user-centeredness of human-computer interactions. Technologies that are able to assess relations of the user's physical action, cognitive processes and knowledge formation have the potential to better address the human embodied way of living. Methodologies for designing and assessing natural embodied interactions need to be developed in parallel with technological advancements.

Recently, major companies working in the area of information and communication technologies (ICT) and services, such as Microsoft, have started to take notice on the importance of choreographic innovation and choreographies' role in increasing productivity. Seamless integration of the user and the computer systems is at the heart of the Productivity vision that introduces a reformation in the human-computer interaction choreography. When devices interconnect seamlessly and new digital resources, such as large embedded interfaces on smart table surfaces, smart windows and smart walls become popular it is no longer meaningful to stick with the limited choreographic possibilities offered by a single device. Instead, interaction design treats user interfaces as networks of digital resources that are characterized by adaptive functionalities. User-driven choreographies enable the user to reach and commission the local resources, such as visual displays, and apply an optimal workflow based on the available resources, task-related needs and social setting unique to a given situation.

My estimation is that the standard quality measures of design outcome in intelligent information and communication environments will be increasingly evaluated on the basis of choreographic designs and whether the interaction choreographies support smooth and intuitive use of device networks. Adaptive networks of devices provide unforeseen possibilities for adaptation of purpose in different contexts. Hence, new models of choreographing the networked interactions will improve the efficiency in the usage of data processing tools. Understanding principles of good choreographic design in increasingly complex application environments becomes a necessity for design of intelligent ICT-environments. Old ways of assessing interaction do not provide sufficient tools for the revolutionized context.

This study strives for activating discussion among design professionals on the avenues to develop intelligent ICT environments into more meaningful places through using our bodies to construct knowledge and collaborate with other people in productive bodily engaging ways. The focus of the study is in application of newly introduced choreographic approach to interaction design in a case study on Microsoft Productivity future visions (2009; 2011). Choreographic analysis is a research method that enables coincident study of different levels and implications of movement dynamics. Analysis starts from the user's kinesphere, referring to the user's body and its' immediate micro-movement continuums, movement's reach and experiences of interaction, and ends up with scrutinizing large-scale societal implications of the industrial choreographies (see Parviainen, Tuuri and Pirhonen, 2013).

Choreographic analysis is seen through phenomenological methodology and kinesthetic research. The methodological and theoretical framework enabled me as a researcher to move within the choreography and assess the embodied interactive experience. I made a re-composition of movement material extracted from the original visions, which was a necessary step to take in making the interaction data into practicable form. Dancing the movement re-composition that I call 'industrial choreography', writing about the experience and a video documentation of the dance became central means to present the research process and findings. The analysis concentrates on assessing task-related choreographies in two areas, first, sharing and fetching digital content and, second, re-modelling data and visualizations. The original technological context is reproduced on the pages of the report through screenshots from the original scenarios introduced by Microsoft, yet it is useful for the reader to familiarize on the original videos that are addressed in the reference list as Productivity future visions, (2009; 2011).

The study shows how the use of information and communication technologies affects the user's body alignment, movement continuums, positions in space and extension of movement trajectories. The study also shows that user choreographies are heavily yet not totally influenced by choices made in choreographic design. The research report presents rich amount of examples and interpretations of ways the design influences user's movement and provides a unique and probably the first case study in this scope that looks at how choreographic approach to interaction design described by Parviainen, Tuuri and Pirhonen, (2013) can be adopted in critical assessment of interaction choreographies on conceptual design stage of an intelligent ICT environment.

1.2 Dance in studying interaction design

This study is entirely shaped by dance both in theory and practice. To start with, the case study can be characterized as a "research dance" where dancing is directly involved in the ways of conducting the research. I did internalize the studied human-computer interactions through dancing. My intention was to embody the visions of possible future interactional logics between the user and computer systems that are embedded in intelligent home, work and transportation environments. Reflections on the choreographic practice and final documentation of the dance in a video format became part of the research data (see Industrial choreography). Theoretically the findings are bound together through the concept of choreography, a concept that was first introduced in the field of dance (see Foster, 2011, p.15–72). Furthermore, the entire research is wrapped together with phenomenological methodology and a specific method called hermeneutics of the body (see Hoppu, 2005) that was first introduced in the field of dance studies.

The reason for adopting this much theory and practice from the field of dance is twofold. First reason is that I personally consider dance discipline to hold absolutely the best understanding on analyzing the felt sensation of movement and the broadest vocabulary to highlight characteristics of embodied skill, body control and technique that are crucial for crafting verbal spatial representations of movement. Secondly, adoption of a holistic set of theory and methods from dance discipline facilitates the creation of a coherent research framework. Nevertheless, empirically the study is firmly rooted in the field of interaction design, specifically, in the emerging area of designing interactive intelligent environments. Therefore the study is contributing to the design discussion complemented by the pronounced loans from the dance scholarship.

Dance studies can contribute more than a metaphor to the field of interaction design. Kinesthetic dance research enables the designers to dance along the design process when internalizing the areas of design problems and possibilities, which could prove as a valuable technique in overcoming the fuzzy front-end phase of design (Cagan and Vogel, 2001). However, there are only a few studies coping with dance and design studies. I managed to find only some crossover studies that look into modern dance and interaction design (i.e. Loke and Robertson, 2010) and some design-driven projects that work with dance art and dancers' movement (see Synchronousobjects) and some essay collections pondering the role of movement for industrial and interaction design (Fejis, et. al., 2005). This study builds on the recently introduced theory on choreographic approach to interaction design (Parviainen, Tuuri and Pirhonen, 2013).

1.3 The concept of choreography in studying interaction design

As a term choreography was originated in dance but as a theoretical concept it has been adopted to a number of various disciplines. Choreography refers to a structuring of movement in space where performed actions and sequence of movement progression can both be referred as choreography. Degree of specificity of a given choreography or precision of the design of its plan of activity defines choreographic freedom. It is possible to designate minute aspects of choreography or conversely "sketch out the broad contours of action within which variation might occur". In one way or another, choreography constitutes a plan or a score according to which movement unfolds. (Foster, 2011, p.2) In the context of interaction design choreography is used to manifest how design choices affect movement and actions. "It includes both the plan for the action, the action itself and all the agents it draws together." (Parviainen, Tuuri and Pirhonen, 2013, p.108–109) Broad definition of choreography makes it possible to pay attention on single movements and gestures between the user and technical interface(s), sequences of movements and connect human-computer interaction choreographies to a broader interactive setting including other characters and actions in space as well as the structure of the space.

1.4 Description of the case and research questions

Smart devices have grown in numbers in an expansive pace and today they influence the lives of billion(s) of people globally. The industry leaders' effect on the emergence of shared global movement vocabularies and the establishment of "dominant choreographic designs" of human-computer interactions has been significant. As a result, individuals in Singapore, Niamey and Boston are compelled to adopt similar kinds of micro-movement choreographies associated with the use of certain technologies, i.e. mobile telephones. The study addresses the kinesthetic experience, and mechanisms of control and flexibility presented in corporate choreography. The analysis adopts choreographic approach to interaction design which is a methodology and framework that enables movement analysis of choreography as the personally felt experience, and the choreography in shared social contexts as well as the macro choreographies of the corporate action (Parviainen, Tuuri and Pirhonen, 2013, p.113).

The case study approaches "industrial choreography" through analysis of movement sequences in a future-oriented user-centred human-computer interaction vision presented by Microsoft. These two publicly available visions are in video format. The videos are referred individually as (Productivity future vision, 2009), (Productivity future vision, 2011) or together (Productivity future vision, 2009; 2011). Study emphasizes two choreographed areas of human-computer interaction, first, sharing and fetching digital content and, second, re-modelling data and visualizations.

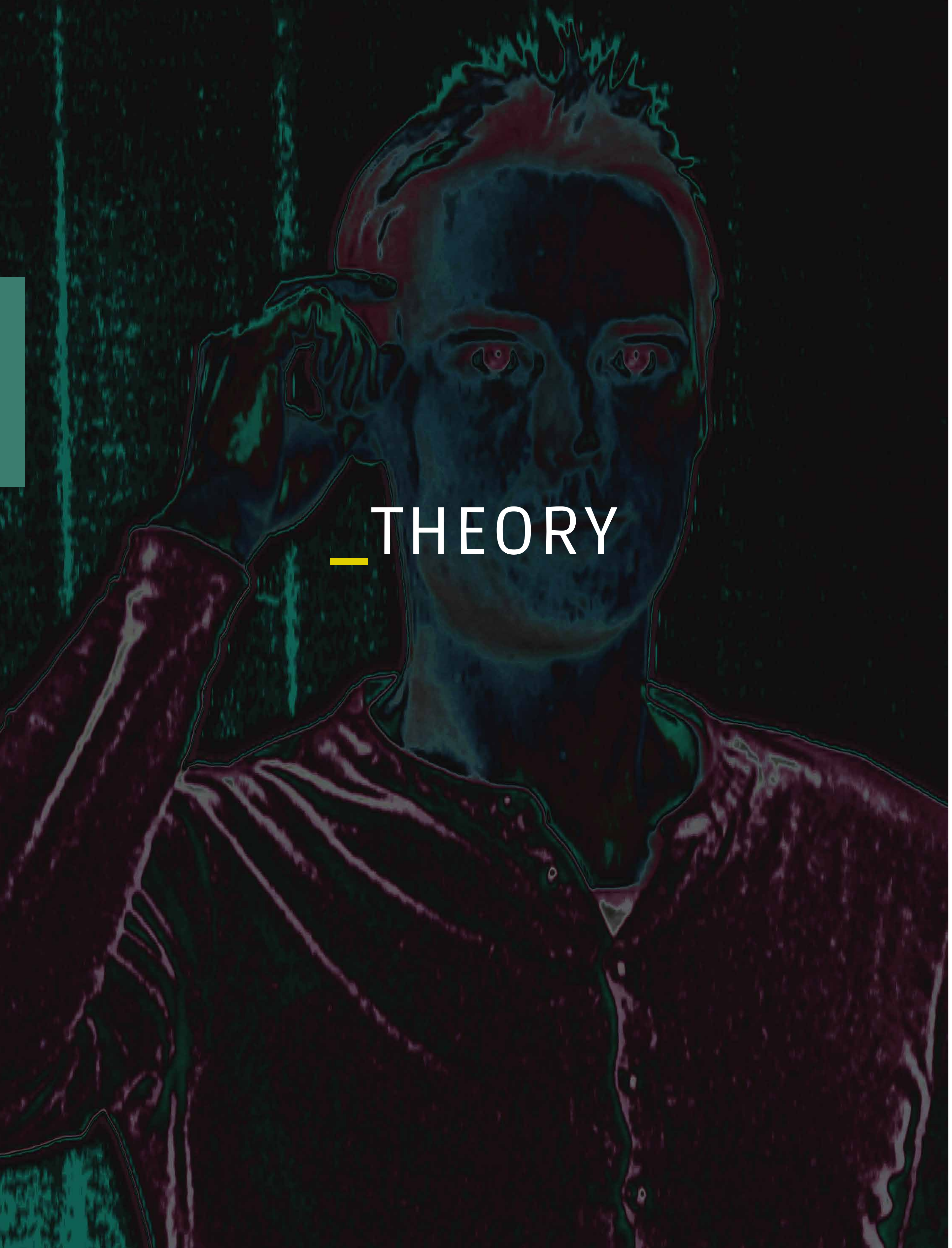
The balance between controlling and enabling the user's embodied actions during human-computer interaction is a focal concern in interaction design. General conclusions drawn from the study are that micro choreographies are to some extent limiting the user to the use of fixed set of devices designed for a specific purpose through predefined movement continuum. However, it is noticeable that the visions present a variety of intuitive and insightful choreographic strategies both in terms of kinesthetic micro movement continuum and social convenience of human-computer interaction. Examples of enabling choreographic designs relate, for instance, situations addressed as local level choreographies that enable the user to make spontaneous spatial arrangements of smart object networks to choreograph collective interaction. Such choreographies significantly increase the user's freedom to optimize the current interaction task. Analysis also revealed some examples of choreographic mistakes that can be experienced as difficult movement sequence or distraction in social communication due to intervening computer feedback. Choreographic analysis elaborates the mechanisms of conforming versus open-ended and enabling human-computer interaction choreographies and these strategies' influence on the user's embodied experience.

The study of intelligent information and communication environment is conducted through an embodied approach that borrows the grounding epistemological and ontological ideas from phenomenology, hermeneutics of the body and kinesthetic dance research. These ideas are used to construct an understanding of 'dancing as choreographic practice' that, became central approach in conducting the choreographic analysis in this study. Since the choreographic approach to interaction design, as a framework, does not suggest any detailed procedures in conducting the actual analysis, methodological development can be seen as one of the key contributions in this research.

Research questions are:

> 1 ***What kind of influences does the choreographic designs presented in Microsoft's Productivity future visions have on the user's kinesthetic experience?***

> 2 ***What kinds of understandings can be created through embodied choreographic analysis of human-computer interaction?***



THEORY

2.1 Computer systems and embedded sensor networks for real-time sensing

Movement-oriented contextual services set demands on the computers' ability to recognize the user's body, movement and intention through spatial and temporal mapping of the user, her environment and her activities. This section looks into the logic of the computer systems to apprehend the user through embedded sensors and gives examples on how this sensor information can be processed and used in service applications in intelligent ICT environments. The overview uses the Microsoft vision's examples (see Productivity future vision 2009; 2011) to highlight some of the foreseen interactions, interfaces, application environments, and use situations in order to ground the presented technological details into understandable real-life context.

Recent progress and convergence in micro-electro mechanical systems (MEMS) technology, wireless communication and digital electronics has introduced miniature devices that are able to sense, compute and communicate wirelessly short distances (Gubbi, et. al., 2013, p.1646). This technology can acquire knowledge both about the environment and its users and apply that knowledge in improving the users' experience in that environment (Kaasinen, et. al., 2013, p.2). Computer needs detailed digital information about the user which can be acquired and delivered through tiny microprocessor chips and sensors that record and transmit data, such as sound waves, temperature, [the user's] movement and heart rate among other possible variables (Swan, 2012, p.218). Sensors can be embedded in the environment or carried by the user. In the Microsoft vision the user's personal devices [smartphone, tablet], wearable technology [smart glasses], furniture and office accessories [smart pens] are equipped with inbuilt intelligence. This data is then turned into numeric information about the device's / user's location and performance. People-centric sensing permits the computer to access environmental parameters as the user experiences the situation. User-centered data can also help the computer to construct a picture of the user's on-going activity as well as the context of a given event (Gubbi, et. al., 2013, p.1657).

Ubiquitous computing does not need to be built on extensive pervasive technologies, such as massive sensor networks that aim at monitoring users' states comprehensively and reacting to them with objective of making decisions for the passive users. Instead the technologies can be harnessed to serve the user as ensembles or ecologies of resources that are composed of mobile and fixed devices, that are built to serve specific purposes, and that can be situated in particular places. (Rogers 2006, p.406) On the other words, people-centric sensing does not mean that the user needs to be wired but the sensor information can be acquired through smart devices and 'things' carried by the user (see Maggliochetti, et. al., p.2012) or smart objects manipulated by the user. Intelligent home, intelligent office and intelligent classroom are presented in Productivity future visions (2009; 2011) as examples intelligent environments equipped with devoted digital resources. Furthermore, vision gives indication about flexible service hubs that accompany the user 'on-the-go' and integrate services and information from different service providers for the user.

Critical concern in the implementation of the intelligent environment is that technologies will not passivize the user who is not exactly using these environments but lives in them with the smart systems inhibiting the same space (see Kaasinen, et. al., 2013, p.5). I share some ethical standpoints with Rogers (2006), for instance, despite the expected major leaps in the technological intelligence and automation, taking the initiative to be creative, constructive and in control of the interactions within the technological environments is an activity that should belong to the user also in the future. This does not exclude the possibility that technologies could be designed to activate and motivate the user through interactions that creatively, excitedly, and constructively extend what people currently do. (Rogers, 2006, p.406) Well-designed interactive environments can support healthy and stimulating life without being intrusive.

A significant character redefining the future technological environments is that everyday products become connected to the Internet and possess computational abilities (Swan, 2012, p.218). Proliferation of these smart devices in a communicating-actuating network leads to the transformation of the Internet. The Internet will develop from current social networking web (web 2) to ubiquitous computing web (web 3), also known as the Internet of Things (IoT) (Gubbi, et. al., 2013, p.1645). By 2020 the number of devices connected to the Internet is estimated to reach 24 billion whereas the amount of connected devices (inter-networks of things) is estimated to reach up to 50 billion (GSM Association, an industry-association for worldwide mobile operators in Swan 2012, p.218). The expected exponential growth of smart objects can be explained by availability of low-cost sensors that provide different kinds of functionalities. Common sensors, such as accelerometers, gyroscopes and sensors for sound, light and temperature are expected to be adopted in various industries, such as energy, healthcare, education, smart home and transportation in a massive scale. (Swan, 2012; see also Microsoft's visions on Manufacturing and Healthcare)

The sensors enable monitoring of the condition of the objects that supports dynamic controlling and adjusting the status of the objects (Lopez, et.al., 2011, p.292). On the other words, smart objects react to their environment following pre-defined algorithms that may even remember and learn from the user's actions and learn to anticipate and adapt to its operation according to the user's preferences (see Nest thermostat). Basic characteristic to the 'things' is that they are readable, recognizable, addressable and controllable through the Internet (Swan, 2012, p.217). Autonomy of the smart objects is also increased through the powerful yet low-cost embedded processing and the wireless communication, such as radio frequency identification (RFID), ZigBee and Bluetooth. Smart objects are often equipped with networking capabilities and local intelligence. (Lopez, et.al. 2011, p.292)

In the Microsoft's vision one of the most outstanding features are related to the devices' capability to wirelessly and spontaneously form ad hoc device networks according to subtle commands of the user. Especially, the sharing of screens between personal and public devices in a hotel room, private house kitchen or at a company office supports spontaneous improvement of interactional possibilities. In the case of a moving person, for instance the travel hub example, the devices' ability of inter-networking becomes the central feature enabling flexible use of "the ecologies of resources" described by Rogers (2006). Other example is related to the ability of sending information smoothly from a device to another. These interactions are not only effectuated by pushing buttons but the vision presents some pretty intuitive movement-controls, i.e. zooming a map on a split smartphone screen as a response to the user's arm's vertical level alteration, touch screen sweeps, i.e. dragging and dropping a file over a tablet border to the screen behind the tablet, and even gesture control solutions, i.e. giving a paste command to a tablet-computer through one single hand gesture. The advances in providing real-time kinematic data (Chen, et. al., 2006; Vogt 2008) are opening unprecedented possibilities for designing movement-oriented contextual services.

Huge increases in processing power can be gained when local smart object networks are connected to databases, data mining tools and computer networks. Links between these system layers are realized through connection hubs and distributed information infrastructures that use the Internet protocols for communication. (Lopez, et.al., 2011, p.292) Unprecedented expansion of data and swiftly improving access to institutional open access datasets demands novel approaches for how to make the numbers "intelligible, usable and useful" (Rogers, 2006, p.412). In addition, this processing should be accomplished so that resulting information is useful for the user's current activity (Ibid.). Clever design of middleware solutions that perform data storage and analytic processes together with data visualizations are crucial for end-user services provided by the ubiquitous computing web. Entering to the era of the Internet of Everything, the need for data-on-demand is expected to increase along with sophisticated intuitive queries (Gubbi, et. al., 2013, 1645, p.1649). The Productivity future vision (2009; 2011) presents many scenarios that require concurrent processing of data both from the environment and from the internet i.e. using visual search engine that augments information directly on the environment seen through a transparent circuit tablet screen.

As a summary, we seem to be heading towards a future where businesses as well as private persons can benefit of ubiquitous sophisticated searches and real-time data processing services. Personal devices will be increasingly used in sync with other devices and embedded interfaces. Locally collected sensor data will be increasingly aggregated with public and private datasets that enable contextual high-end information services. Successful design of contextual services necessitates but clever orchestration of computational resources, also thought through choreographic design for the human-computer interaction choreographies.

2.2 Interfaces for choreographing human-computer interactions

When computational resources are to be combined with cognitive and kinesthetic capabilities of an individual user an interface between the human and computer agent is needed. In the Productivity future vision (2009; 2011) the dominant operating principle of the user interface is simple and consistent: The user communicates to the computer through pushing, sweeping or turning a tangible user interface such as smartphone screen or embedded wall interface. The computer, instead, creates augmented visual feedback on the same visual displays that the user touches or on other proximate visual interfaces that are involved in the interaction via device network. The computer feedback is generally presented as abstract task-related visualizations, mostly in form of lines, curves, gauges, bars, or points (see also Yang, Bischof and Boulanger, 2008). Augmented visual feedback is mostly concurrent, which means that visualizations are presented during the user's performance and visual feedback influences directly on the user's sensorimotor action. On the other words, visual feedback becomes part of choreographing the task itself.

Technological products can be labeled as tangible user interfaces (TUI). It is noticeable that the Productivity future vision (2009; 2011) does not present any recognizable technological products but plays with mere ideas on shapes, sizes and functionalities related to different technological form factors. From choreographic perspective, an interesting remark is that differently shaped objects can be addressed with commands that differ significantly from those associated with other sized objects and these possibilities are widely used in the Productivity visions (2009; 2011). The shape of the objects is mostly rectangular and their size varies from a business card, smartphone, tablet and tabloid to even bigger sized screens that are integrated in tabletop screens, windows and walls. These devices and their combinations have their characteristic ways to be interacted with. The availability, positions and sizes of technical displays in space relational to the user's position, interaction task and social situation define the choreographic contour from within the on-going interaction choreography unfolds. Additionally, the user's knowledge, skill and capacity to use the devices' ability to establish device networks, especially when combined with clever spatial design and positioning of different devices in spaces, broaden choreographic possibilities. Through dynamic re-combination of devices the user can move data as well as device controls from one device to other.

The user is immersed in the intelligent ICT environment and thus the use interaction is not restricted only to interactions between the user and a device, i.e. a smart phone. Instead, the user's body situates on the interface and controls its' position, directionality, speed etc. within the physical-digital space that is, at least momentarily, aware of the user's embodied states. For this reason also the body of the user needs to be considered as a controller of the interface, which leads to considerations on how the physical space and positions of technical displays should be designed to enable optimal use of the user's body-in-movement in the operation of the interface. The body is the user's primary mean to interact, i.e. send direct and indirect commands to the computer and interpret computer feedback. The body is constitutive element for interaction that integrates various affordances and suggestions into a meaningful choreography.

When designing choreographies for intelligent ICT environments, the user should not be understood as something separated from the 'thing world' that she interacts with. Instead, it could be argued that the body is what it is because of 'its unparalleled ability to co-evolve with things.' Usage of different smart objects, as if bringing augmentations to different parts of the biological body, shows the human body as a constantly evolving distribution of different hybrids with different reaches. These new reaches provide opportunities for new mediated, mixed and augmented experiences (compare Thrift 2008, 10; Poutanen and Kelaranta, 2014). This statement brings smart objects into the sphere of embodied movement and enables considerations where smart devices are seen as constituents of the choreography defined by the user's hybrid-body-in-movement.

User internalizes embodied human-computer interaction skills in repetitive practice of living and interacting in smart home, work, transportation and education environments. If the practiced movement sequences follow homologous patterns in terms of positioning technical displays, adopting similar shapes and sizes of the displays and applying logically established augmented feedback strategies, the user's skill in interacting within a familiar environment can be applied in other physical contexts (see also Oakley and O'Modhrain, 2005). The Productivity future vision (2009; 2011) suggests that similar kinds of interfaces that can be addressed with identical micro-movement choreographies will be installed in varying everyday environments, which would support broader application of embodied interaction palettes. Broader applicability of personal interaction skills will generate return on personal investment in learning not just basic interactions but also more advanced movement sequences for sophisticated interaction. It is important to make learning interaction choreographies meaningful for the users.

2.3 Kinesthetic foundation of subjective interactive experience

Kinesthesia derives from the Greek words kine and aesthesis, and altogether kinesthesia refers to movement sensation. The term first emerged in 1880 when research had established the existence of nerve sensors in the muscles and joints and the sensors' ability to register the body's movement. The term kinesthesia became more widely used in the 1970s with the work of psychologist James J. Gibson who created a notion of senses as perceptual systems. According to Gibson the perception is an active process of extracting information from the environment. Making sense of sensuous stimuli is a result of complex sorting of different sensory information affected by situational characteristics. Gibson concluded that the person and her environment together constitute the perceptual system. (Gibson in Foster, 2011, p.3, 7, 74) Based on Gibson, I argue that the user experience always encompasses the situational context which influences on the user's perception and thus the experience.

The movement experience is constituted of constant flow of internal and external feedback. The internal sensory feedback, also known as intrinsic or proprioceptive feedback, provides continuous sensations about our body, its posture and movements whereas external, also known as exteroceptive, feedback connects ourselves to the environment and helps us to locate ourselves in our immediate context. [On alternative definitions see Smyth, (1984)]. The same sensuous modalities are used in making sense of both internal and external conditions, for example, visual kinesthesis is the sensation of movement of one's own body when the movement is seen (Smyth, 1984, p.19). For Gibson the perception was not mere a sum of information provided by the individual senses but a result of integration of different sensory stimulus. According to his studies, kinesthesia plays a central role in the integration of different sensory input (Foster, 2011, p.3, 115–116).

Technologically augmented interactions manipulate the user's perception about her environment in on-going activity. Therefore interaction choreographies should be designed so that user's internal and external sensations are taken into account. For instance, a widely used interaction in Productivity vision (2009; 2011) is to give a tactile command through a mediating device to a proximate vertical display; this interaction creates internal haptic feedback when the user grabs the mediating device, turns towards the vertical display, takes the position to order the device and finally makes the command that also generates tactile feedback. Visually the user perceives both her body-in-movement and the visual augmented feedback on the devices' states in the environment that inform her on the computer system's state. Nevertheless, listing down perceptual progression is not the point. Kinesthetic sensation is impossible to apprehend from the outside and it is extremely difficult to verbalize or understand based on any representation. Therefore it is not enough for interaction designers to stick with the movement appearance without experiencing it. In the optimal case "mediating interfaces should become [...] such an extension of a body that fuses with the sensorimotor schemas of natural interaction" (Parviainen, Tuuri and Pirhonen, 2013, p.105). Embodied assessment of the choreographies in relation to the intended real-life context is thus always needed.

Since kinesthesis refers to the nature of communication and not to the perceptual system by which the perceptual information is picked up kinesthesis cannot be used as a referent to a channel for input in the similar way than auditory, haptic or visual channels. Rather kinesthesia is a process where perceptual information from 'sovereign' channels relates to the movement system of the observer (Smyth, 1984, p.19). Therefore the understanding of kinesthesia requires rudimentary understanding on perceptual systems that can be technologically augmented. Understanding on auditory, haptic and visual perceptual systems and their contribution to kinesthetic experience can be considered as basic knowledge for interaction designers that work with creating service applications for intelligent environments. In this research tactile and visual perception is in the central role, consequently, the following sections concentrate on discussing these modalities.

2.3.1 Haptic-tactile perception

Many sensations can be represented as if they existed outside the human body– images and film for vision, recordings for music – but for touch the human body is the ultimate reference. How we perceive our body and its' movement in the environment is always experienced in relation to the body's size and orientation, its own relative motion, body temperature and humidity relative to the surrounding environment, as well as individual haptic capabilities on tactile surfaces of our body. Gibson proposes that touch consists of two different faculties. First is pressure on the skin that explains how we experience contact between the body and its environment. Second faculty is kinesthesis, which refers to the body's ability to perceive its own motion. For Gibson touch is about awareness of presence and of locomotion. (Gibson, 1986) Haptic modality is present in the case study in rich diversity of tangible user interfaces in different shapes, sizes and movement choreographies related to particular shapes of objects.

Skin is essential to the functioning of the haptic system. The skin is the largest organ in human body and our outmost direct means for tactile exploration of the world. Receptors in our skin, muscular system, joints and tendons provide us haptic stimulus. Through the haptic system we can extract information about the form, size and weight of objects and their movement. Haptic sensuous information is largely received passively (simple touch) but when there is interaction, for example picking up objects and manipulating them, touch becomes actively involved in making sense of the world (exploration and communication). (Rodaway, 1994) When interacting with mobile devices and embedded interfaces, the feel of the device surfaces and continuum of different positions performed by the body during the interaction are critical user experience concerns that should be assessed relative to choreographies.

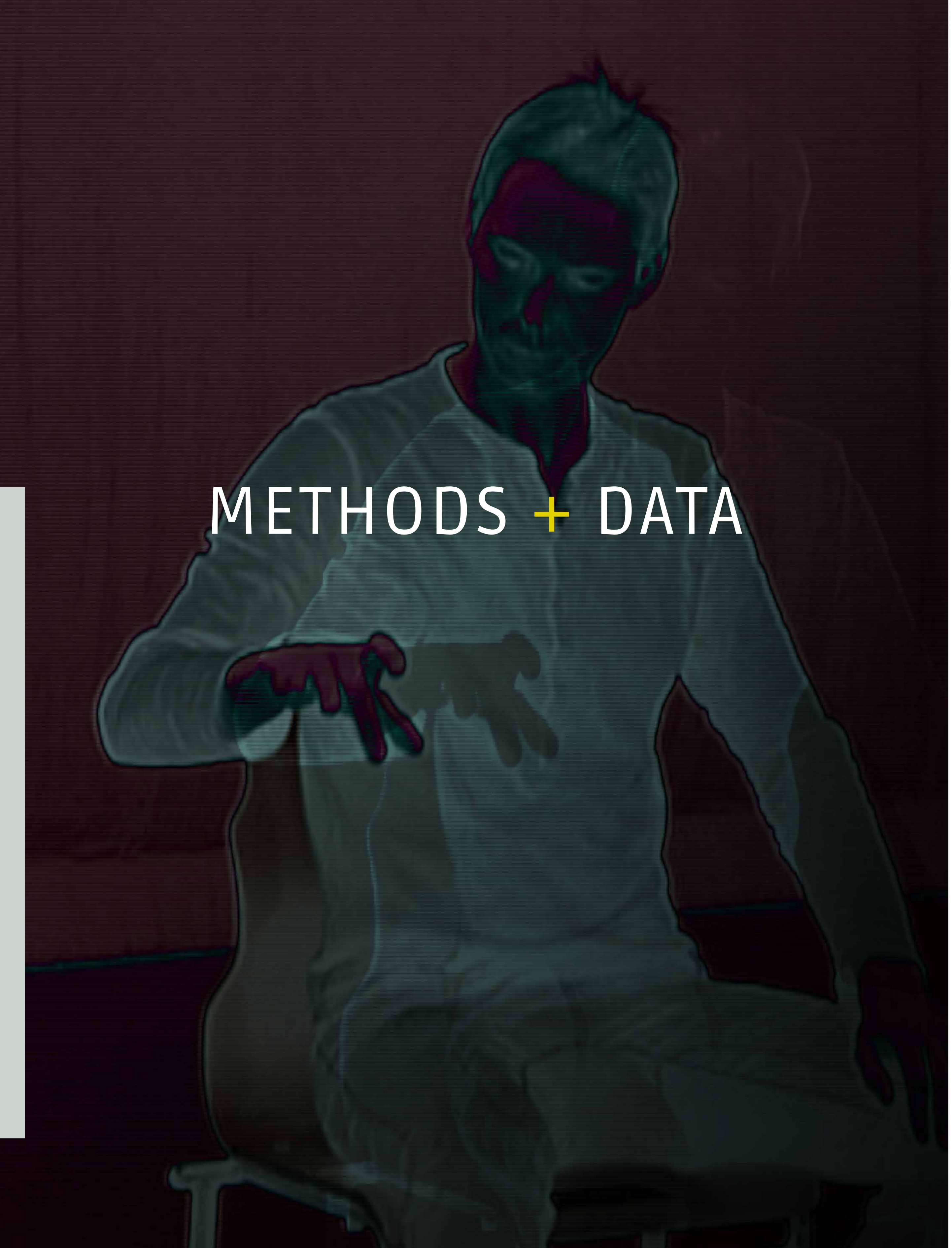
Movement and the specific upright posture that leaves our hands free for exploration and geometry of the body enable versatile tactile exploration. The body's ability to locomotion enables touch to become mobile. In movement our body is continuously assessing its speed, distance it has traveled and, it can even recognize familiarities in three-dimensional movement progression, such as routes familiar to the experiencer. The body can recognize sequences of specific movement patterns – curves, stairs and angles –and their organization as familiar routine activities. Haptic perceptual system can be argued to give human the understanding of volumes and, thus, through touch and locomotion we create the abstractions that help us to understand spatial dimensions. (Rodaway, 1994) In this regard, also the spatial design and the commonly experienced movement trajectories in space need to be considered when considering choreographies of interactive spaces.

Haptic perception builds on contrasts and continuities within and between objects. Hence, detailed understanding of an object's tactile qualities cannot be acquired through one simple touch. The movement of a limb on an object or a surface helps the experiencer to extract information about the shape, size, and depth of volumes, and numerous circumstances about the various textures, temperatures, plasticity, flexibility, squishiness, and continuity of surfaces. Information can be extracted especially if the movement is relatively slow. The haptic system works in collaboration with the brain and together these systems organize haptic stimulus to coherent tactile sensations that help the experiencer to recognize and make sense of the features in the environment. (Rodaway, 1994, p.44) Cleverly designed combinations of material choices, object shapes and spaces together with choreographies that unite these individual design choices into a coherent experience can significantly influence the haptically-derived kinesthetic experience.

2.3.2 Visual perception

Gibson (1968) states that vision is an active and exploratory process where sense organ in conjunction with the brain receives an optical array of information from which the colors, surface textures, distances, arrangements of objects, movements and depths are discerned. Visual perception is also highly dependent on light that is reflected from the structures in the environment – when it is dark human ability to see is strongly impoverished. Objects in space structure the ambient light that reaches our eyes and, therefore, vision is spatial (Rodaway, 1994, p.121). Sight gives access to surfaces and thus it is concerned with appearances. However, vision is a deductive sense that allows us to end up in quite detailed analysis of what we see. In the process of seeing we are able to associate our experience and memories of other sense modalities, e.g. haptic, olfactory and auditory, that complements the information of what we see. (Rodaway, 1994, p.117) The ability of visual perception to support individual in perception of spatial dimensions makes vision extremely important sense for choreographic design. Choreographies do not unfold only as human-object interactions but, referring to Gibson, the context is constitutive for the perception and thus realization of interactive tasks that the user experiences as an event.

The ability of the human eye to distinguish between colors, shapes and materials of objects enables us to differentiate and classify objects and surfaces. Classifications are based on optic clues; the visual perception system gathers different information of how light is reflected from the objects we observe – light colored surfaces absorb less light than darker ones, reflection of light from rough surfaces may be more dispersed whereas sleek surface reflects light more coherently. Also textures and topography affect to which direction(s) light is reflected. As a combination of the structures and properties of the environment we can perceive overall reflectivity across our view. This view enables us to form a 'picture' of an environment consisting of different objects, surfaces, materials, forms etc. distributed in space. (Rodaway, 1994, p.121) The 'picture' of the space influences on how the user perceives the resources in the space. This makes vision as key channel through which the user perceives the positions of visual displays in space. How these displays can be perceived from different positions in designed space during the interaction choreography characterized by the body-in-movement is a critical consideration from the perspective of choreographic design.



3.1 Methodology – Phenomenology

3.1.1 Body and the experience of movement in kinesthetic dance research

Phenomenology enables movement experience to be emphasized as the main interest of the study. Phenomenological thinking also provides methods and approaches that acknowledge the knowledge of the body (Hoppu 2005, p.109) and offers helpful ideas for giving form to an experience (Hoppu, 2013). When the researcher is considered as an experiencing subject and her experience as relevant research material the researcher cannot look the researched phenomenon from the outside but she becomes participant to the phenomenon. In this study, dancing a re-composition of choreographies extracted from Productivity future vision enabled embodied assessment of interactions in not-yet-existing intelligent information and communication environments. Yet the understanding of the context remained on abstract level, my body moving along with the choreography opened up a unique position to assess the kinesthetic dimension of experiencing these environments.

When I write about the process of embodying industrial choreography I use the term 'dancing'. With dancing I refer to embodied understanding on the subjectively felt essence of socially and technologically constructed movement. Furthermore, dancing is an embodied skill that enables me to perform a representative sample of movement material extracted from the studied interaction choreographies. This skill is demonstrated through a video document on the re-composition of the original choreography. The link for accessing this dance can be found in the reference list (see Industrial choreography). Dancing describes my interpretation of a possible application of phenomenological principles in choreographic analysis. I consider dancing as a way of thinking and processing information. Dancing helped me in organizing the movement material and assessing the choreographies' effect on my body and experience. Documentation of the dance became part of my analysis and an independent argument on the effects of technologies on our body. Due to the importance of dancing in the study I consider myself as a dancing researcher (see also Hoppu, 1999; Poutanen, 2014).

Research reports often bypass reflections related to the existence of the researcher's body and its role in the process of research. However, when somatic knowledge is to be understood, described and analysed, complete bodily engagement of the researcher holds the central stage in the research. The felt dimensions of movement experience can be approached only through the researcher's body. (Sklar, 2000, p.71) The knowledge of the body is explicitly addressed in kinesthetic dance research. Scholars within this orientation share the assumption that the researcher's knowledge cannot be separated from dancing. Instead, the act of dancing accumulates tacit knowledge into the body of the researcher, that is, dancing turns the researched phenomena into body's knowledge, which makes dancing as indispensable part of the research process (Hoppu, 2005, p.106).

On the other way round, the body exercises its knowledge through movement, which can be considered as a primary way of a human being to make sense of the world and make a commentary about it. The knowledge of the body is complex and mostly nonverbal. Body has the knowledge of its own that is neither mediated by language nor a stepping-stone to language . (Sheets-Jonstone, 1999 in Parviainen, 2003, p.163) This means that the body has its own way of mediating our experience of being-in-the-world that is affected by our past experiences, about our perception of the current situation and our expectations about what we expect to happen. This knowledge should be understood as unique ability of the body that cannot be subordinated by linguistic representations.

Deidre Sklar describes dancing as a practice of research that can be described as somatic mode of apprehending. This refers to a research method where the researcher does "attend to doings with proprioceptive awareness". (Sklar, 2000, p.71) Here proprioception refers to reception of stimuli that informs about the body's internal movement (on definitions see Smyth, 1984). Somatic mode can be attended through practice where there is sensitivity to the felt experience of kinetic dynamics of movements, sounds and images. Practice develops a body that is skilful to apprehend nuances between dynamics in her movement as well as depicting kinetic sensations from the other dancers' movement. Wording of kinesthetic experiences can also be learned and studied. (Sklar, 2000, p.72)

3.1.2 Hermeneutics of the body

When moving or seeing others move, the nature of the major part of incoming information is tacit. It means that I have no explicit access to what I know but I can still use the knowledge somehow (see Polanyi, 1966, p.7). Conventional scientific methods are not suitable in analysing tacit knowledge and, therefore, a different perspective both theoretically and methodologically is needed. Hermeneutics of the body, that, according to Petri Hoppu, builds on the writings of 20th century philosophers' thought, especially texts of Wilhelm Dilthey, Martin Heidegger and Hans-Georg Gadamer, presents a perspective to alternative science that connects research and dancing (Hoppu, 2005, p.106–109). In hermeneutic analysis the researcher is in contact with his object of research and, while the researcher gains new insights concerning the object, his prejudices are constantly changing. The basic idea of hermeneutics can be abstracted as a spiral representing a process that deepens the researcher's knowledge of the research object. (Hoppu, 2005, p.107) When the felt dimensions of movement is the object of research, the researchers' own body and the memories carried by the body can be seen as the primary resources of the researcher. The body is a mean to acquire knowledge of the movement and – through understanding "qualitative and associative nuances" of the movement – the body provides the researcher ways to language. (Sklar, 2000, p.75)

Traditionally, hermeneutic analysis begins in the 'field' where the researcher meets the living practice of movement. During this phase the researcher also writes about her experiences. In this research, fieldwork phase refers to learning and performing the choreography. Active writing was a central element in this phase of research which encompasses learning to perform the movements – continuums of body postures, limb movements and sensuous focuses reaching out to the surrounding space – understanding meanings of the interactions and interpreting the nuances relating to micro and local level choreographies in task-based activities. During and after the fieldwork I compared what I had written about my experiences to my feelings and skills (compare Hoppu, 2014). During the fieldwork my entire body was used in making observations and, therefore, the hermeneutic process is to a great extent a matter of corporeal experience (Hoppu 2005, p.107).

In this study the researched context, Productivity future visions in video format, did not allow me to conduct fieldwork through physical participation in the studied events. I was thus unable to share the experience together with other people or collect data on 'lived experience' with traditional means, such as observations and interviews. Therefore I composed the industrial choreography, which is basically a choreographic continuum that encompasses all the most relevant movement sequences from the data regarding to the studied tasks. My reconstruction of the original choreographies became a mobile resource that I could perform whenever and wherever I wanted. I used this flexibility by practicing the choreography in different locations. In this case the term 'fieldwork' is, on the one hand, much more flexible term that it often is when study addresses strictly geographically rooted social practices but, on the other hand, this type of fieldwork is heavily restricted in its potential of mediating understanding on socio-cultural practices and physical places that have an influence on the interactions. Immateriality of the interaction context emphasized the necessary role of my body as the context of integrating knowledge gained from parallel channels – namely, Productivity future vision [watching the video and writing about it], re-composition of the choreographies [dancing], and theory on intelligent environments [reading and writing]. My body became an instrument of constructing embodied understanding on the context that gradually enabled tacit knowledge of dancing to be translated into explicit analysis of intelligent ICT environments.

3.1.3 Constructing embodied understanding on intelligent ICT-environments

Embodiment can be defined as the physical form, realization or expression, or the incarnation of an idea or principle attached to the body (Hoppu, 2013). In this study I relate embodiment to an idea of 'dancing as choreographic practice' that offered ways to acquire and internalize knowledge about intelligent information and communication environments. Embodiment of the ICT context happened through binary process of integrating the knowledge of the body accumulated in the choreographic practice together with insight gained through watching the characters perform interactions in the original Productivity future vision. The allocation of time to watching the videos exceeds slightly the time spent in dancing the actual choreography. Investment of couple of hours in watching the videos enabled me to see both of the videos about 20 times. Watching happened during an extended time span but mostly slightly before, during and after the dancing practice. Combination of watching the original human-computer interactions and dancing the choreography made it possible to assimilate two sides of the phenomena – the experiential and contextual – into a coherent understanding. Altogether I claim that the overall process of integrating knowledge can be well described by the hermeneutics of the body described by Hoppu, (2005). Moving along the hermeneutic spiral through repeatedly visiting the different datasets was useful in deepening my knowledge on the object of research – the interaction choreographies in intelligent ICT environments and their influences on the user's movement and experience during selected task-related interactions.

Watching the Productivity future vision was equally important as dancing the choreography. The visual presentation of the users in the original videos (Productivity future vision, 2009; 2011) and their interactions with the technology communicated to me because the users' movement created response within me. Seeing others move is as kinesthetic as moving self since seeing movement appeals to my inherent sense of motion (Anderson, 1974, p.9 in Smyth, 1984, p.19). Seeing and hearing movement has the ability to activate parts of my neuro-muscular system as well as create responses in the muscles of my body (Smyth, 1984, p.20). My ability to pay attention to details in the visions improved when I started crafting the re-composition of choreography. Furthermore, when dancing and making written notes of my observations was a key moment in the process of translating the tacit kinesthetic knowledge into contextual descriptions of choreographies influence on the body and movement experience. Parallel processing of the data can be considered as the essential part of the embodied research process. Understanding the phenomenon necessitates constant negotiation between tacit and explicit knowledge (Hoppu, 2014).

The process of assessing the inner sensations of the body can be understood as "awareness of experiencing what one is expressing" (Sklar, 2000, p.72). This expression is ambiguous, yet I see it relevant to this study. The technological context in the Productivity future visions could not be accessed as a physical setting but, based on my knowledge on the appearance of the physical space, positions of technical displays and interaction choreography between the user and the network of smart devices, I was able to perform expression of being and interacting in that space. In the beginning a lot of dance practice was needed in order to shift my focus of attention from coordination of my choreographic performance to the expression of being in the precise intelligent ICT environments that each micro-movement sequence referred to. After all, each micro-movement sequence had been presented in context in the Productivity future vision.

In the beginning it was extremely difficult to maintain awareness of expressing choreographies as if being immersed in the intelligent environment. Instead fluency of my expression improved gradually. The culminating point of embodied assessment of the intelligent ICT context was when I could integrate visual focuses in my expression. This meant addressing my conscious focus to exact types and positions of interfaces in the immediate space I was dancing in. First of all I paid attention to spatiotemporal progression of visual focuses in space. Second focus was the influence of extension of visual focus on devices that possessed different form factors, i.e. size, shape, orientation, and relation between the user and the device in space. I noticed that the relationship between the user's position, i.e. sitting, standing or walking, and the device's shape and position in space had noticeable consequences to the posture of the user. Furthermore, the changing spatial visual focuses in the interaction where the user manipulated the objects mostly through touch had an influence on the total experience of the individual micro-movement sequences. The statement that knower constructs the knowledge and thus embodiment is a fundamental mechanism in any learning process (Gale, 2010, p.220 in Hoppu, p.2014) pretty literally applies in this process where no individual source of information – theory on intelligent environments, danced movement experience, Productivity vision's interaction contexts – could have had provided the full picture necessary for conducting the choreographic analysis.

Central ideas on the organizing principles of micro-movement continuums and functionality of the choreographies emerged during the dancing. These findings include advantages of the device networking that enable spontaneous user-driven choreography where the user defines the combinations of resources based on her needs in the on-going interaction. I also gained knowledge on what kind of implications did the positioning and combinations of different form factors of technical displays have on the user's body and movement. All this indicates that, based on the experiences of this study, dancing as a choreographic practice and a process of embodying understanding on intelligent ICT environments can be held as a successful approach to embodied information processing.

3.1.4 Tacit and explicit knowledge

When comparing the written field notes to the experiences, feelings and skills one cannot readily follow logical reasoning, but rather, the focus is on translation of tacit to explicit knowledge. Writing about an embodied phenomenon leads to a reification of tacit knowledge since full verbalization of an experience is never possible due to the limitations of the language (Kuronen, p.197, p.17-18; Biagioli, 1995, p.79 in Hoppu 2005, p.108–109). Structural problem of transcribing movement experience into language is that embodied movement is inherently parallel multisensory experience, whereas language is always sequential. Language encourages the researcher to approach multisensory experience through sequential thinking that radically reduces the essence of movement (compare Ahn, 2005, p.100). Anyhow, the purpose of writing is not to repeat the events representative to the studied phenomena but rather make an interpretation of it (Hannula, 2007, p.245). Therefore text can serve as a tool for reducing the complex relations of the construction of reality (Koskinen-Koivisto, 2010, p.4–5).

Alternatively, it is possible to see the tacit and explicit processes as a reciprocal process of the body where the body becomes what it organizes. For instance, when reading, the words I see have the potential to evoke their somatic references so that I can feel described sensation in my body and, correspondingly, after practicing specialized movement I can explicate some feelings and ideas of the experience through words to other person that can have a somatic idea about what I have experienced. When described this way, the process of the body appears as meaning-making and body-making where there is no conflict between somatic and verbal experience. Thus physical movement and verbal reflection can be seen as "mutually generative, part of the same epistemological process". (Sklar, 2000, p.74) Consequently, when moving deeper along the hermeneutic spiral, I was able to gains skills that enabled me to understand the choreography related to its context. I also became more explicit in writing about the felt experience of the interactions. My personal experiences and research diary notes enabled me to write about the physicality of the embodied interactions.

Bodily activities in kinesthetic research, such as dancing, observation, interpretation and analysis results in major presence of the researcher's actions within the research material. This kind of research can be evaluated as qualitative research in which the researcher's involvement in the phenomenon and her influence on the research data is dominant. This case was tricky because I tried to give explicit form to an experience without the support of any written texts from previous studies; consequently, I did not have words for everything I had embodied knowledge of. Transparency of the research and reflectiveness of the dialogue are central to overcoming these challenges when reporting the research process. (compare Hoppu, 2005) According to Hoppu, in this kind of a research process the transparency issues need to be addressed properly. Research process is transparent when the researcher tells as widely and honestly as possible about the details of the research process so that the outsider can learn about the special character of the work and research material. (Ibid., p.109) The research process concerning this study is reported in the case study section.

All the tacit knowledge does not need to be presented verbally. Whereas tacit knowledge can never be comprehensively verbalized (Polanyi, 1966, p.23–25) it can be performed (Biagioli, 1995, p.79 in Hoppu, 2014). In order to, first, show that the interaction choreographies really have a direct influence on the user's body and, second, as an attempt to convey some kinesthetic feelings related to dancing as a practice of analysis I decided to make a documentation out of the dance practices I used in conducting my study, see the video (Industrial choreography).

3.2 Research strategy – Case study

3.2.1 Challenge of the case study

Case study research sets a challenge for the researcher since there are practically no routine formulas for conducting a case study (Yin, 2003, p.57). Also in this research the case study approach was designed during the research process for this particular research. Since the research strategy appeared in course of an emergent research process, meticulous attention is paid in presenting central research choices and their justification to provide a full picture of the research. Research process description intends to improve the transparency of the study: through giving a detailed description of the research design process and presenting the arguments for the choices made it is possible to evaluate whether the study has followed systematic procedures, bases on convincing evidence and is suggesting relevant conclusions that are coherent to selected research theory and treatment of the data (see Yin, 2003, p.10). Case study is not a method but a research strategy within which various data sets and methods can be applied (Laine, et. al., 2008, p.9; Yin, 2003, p.14). Therefore various methods used in the case study will be presented within the description of the overall research process.

3.2.2 Beginning from the research theory

Research methods cannot be used to define a case study but a case study has to be defined starting from its theoretical orientation (Hartley, 2004, p.324). The starting point for the study was my interest towards the movement-oriented interaction design theory (see Parviainen, Tuuri and Pirhonen, 2013). I was especially interested in applying choreographic approach to analysis of a practical example concerning interaction design for an intelligent ICT environment. Selection of choreographic approach as a background theory connected the case study with the interaction design tradition and provided theoretical means for structuring the analysis. I appreciated the multi-level analysis structure in choreographic approach because it seemed to provide holistic and detailed perspective for analyzing the movement experience of the user slightly before, during and after human-computer interaction.

Having a selected theory and understanding of the relation between the research topic and the theory prior to the conduct of any data collection can be recommended in case study research. The theoretical propositions frame what is being studied and help the researcher to construct a palette of related methods and focus her observations in the data collection phase (compare Yin, 203, p.28). However, a case study may also begin with "rudimentary theory or primitive framework" that enables the researcher to learn about his case and develop theoretical frameworks according to study findings and emerging paths for theoretical structuring. Nevertheless, the theoretical framework needs to be construed sooner or later because without a theory the study may not be able to present any relation between the case and wider significance of the findings, no matter how fascinating the collected data might be. Theory is the central tool of making sense of the data and ensuring the plausibility of the research. (Hartley, 2004, p.324) On the other words, theory based analytical frames are needed to bring abstract ideas closer to empirical research objective. Analytical frame can be clearly defined from the beginning of the research, it can be flexible or it can be derived from the research data [original expression in Finnish: aineistolähtöisyys]. (Laine, et. al., 2008, p.20)

Despite my studies on theory prior to starting the field-work and data collection it remained pretty unclear to me what the choreographic approach could mean in terms of design practice. Thus I conducted the first data collection phase, social dancing event in Otaniemi, as Hartley (2004, p.324) suggests, based on a rudimentary understanding on the research theory and its relation to the case. The organizing of the first case study event was also triggered by "experience of urgence" since I had been working with the research for over half a year without being able to take concrete steps with data collection. Awareness of time passing led me to adapt a somewhat now-or-never mindset. Frustration at this part was mostly due to the difficulty of finding appropriate methodology that would have enabled a natural framework for kinesthetic research; I wanted to dance as part of the study and adapt choreographic approach to design practice through my own body. Hence, selection of a movement practice where the reflection of kinesthetic quality of the activity is inherently present – social dance – felt as a natural topic in respect to my interests. I had a strong emphasis on understanding multi-sensory movement experience and human interaction with tangible, auditory and visual interfaces. At this point I did not consider the technology as necessary factor in the study which aimed at rather theory oriented outcome.

3.2.3 Collecting data for the first case

I contacted organizer of Katulavatanssit social dancing events. We made dancing in Otaniemi to happen in one week notice. Regardless the tight schedule I was able to recruit some of my friends to help me with the documentation. Finally I had three people taking photographs and one person shooting video. I wrote observation notes during the two-hour event. The organization of data collection combining different methods is a typical example of a multiple methods case study; this type of research often addresses issues which can be best pursued through multiple methods, such as direct observation, ethnography, interviews (semi-structured to relatively unstructured), focus groups, documentary analysis and questionnaires, or in combination (Hartley, 2004, p.324). As I have presented previously, I am looking the whole data based on phenomenological method. Phenomenological approach enabled me to consider the Otaniemi dance event from the perspective of lived experience of the dancers. The emphasis of inspecting the data was on movement, at this point, loosely connected to the choreographic theory. First phase of my analysis was to transcribe my observation notes into a narrative that enabled me to memorize the chronology of the events, which is a commonly used strategy in case studies (Yin, 2003, p.125). Second phase of gaining understanding on Katulavatanssit as a social dance practice happened through participation in two dancing events. Personal participation in a dancing event provided a deeper understanding about the phenomenon. I managed to got an idea of the rich nuances of movement experience associated with dancing in urban space.

Figure 1: Impressions from the Katulavatanssi event at Otaniemi campus / Glen Forde

Within two weeks from the dance event I conducted five unstructured interviews with dancers who had participated to the dancing event in Otaniemi. I recorded and transcribed the interviews which resulted as textual data. Texts gave more in depth insight on the situations mentioned in the observation notes, pictures and video documentation. In the interview I covered questions such as the choreographic interactions between dancers as well as interactions between a dancer, objects and structures during the dance event. I also asked dancers' interpretations of the event in general and asked personal questions about the dancers' relation to their bodies and dancing as a free time activity. Against the suggestions in case study literature, at this point I lacked articulated theory and logic which would have helped me to operationalize the case study design and research (see Yin, 2003, p.19) which lead me, unintentionally, to a situation where I got overwhelmed by my research data (see Hartley, 2004, p.329) and did not have a clear idea about how to proceed with it.

3.2.4 Reformulating the research theory

Following the ideas presented in my research theory, movement-oriented interaction design and choreographic approach, I started to concentrate on kinesthesia, the felt sensation of movement, which "has a central role in what kind of interactions with digital devices we consider meaningful and immersive" (Parviainen, Tuuri and Pirhonen, 2013, p.109). In the context of interaction design kinesthetic experience is understood to emerge depending on how the user moves his body in handling the objects and how the object's materiality responds to the user's movement. (ibid.) First of all, I wrote theoretical chapter about kinesthesia and, second, I begun to write about the dancers movements based on my observation notes, the pictures and the video material. From this basis I started to sketch a definition of patterns in the dancer's bodily engagement with their environment, with the other dancers and with objects in the specific embodied culture of Katulavatanssit as a particular practice of social dance. In my initial description I called my findings as social choreography of Katulavatanssit. This kind of analysis was in line with the idea of using case study method in retaining the holistic and meaningful characteristics of real-life events and researcher's "desire to understand complex social phenomena" (Yin, 2003, p.2). How these ideas would relate to design practice remained – at this point – pretty unclear to me.

Despite my absorption and detailed analysis of embodied mechanisms and experienced meanings in social dance, at the first meeting, my supervisor from the design department did not see the dance case study as sufficiently rooted in the design discipline, hence I excluded some of the analysis out of the study and begun to seek more technological context to "exceed the gap from dance to design". I was intuitively convinced that the dance case could bring something valuable to the design discussion and consequently I did not want to completely abandon it. The intuitive feeling or initial knowledge suggesting that the case might be important is recognized as well within the case study literature. Often the meaningfulness of the case can be evaluated only at the end of the study (Laine, et. al., 2008, p.10). On the other hand, the meeting with my supervisor functioned as a wake-up call and pointed out that I really needed to take my disciplinary traditions into consideration and think of the value of my work from the perspective of design research and practice.

Following this discussion, I started the framing of my research topic from the beginning. In the previous round I had started from an interesting case from personal perspective and then proceeded to think about what kind of concepts would fit in analyzing it, what the case reveals and what is the research objective. For this second round I departed from a case study focus that was somewhat imposed on me due to my background theory – the technological human-computer interactions that I would analyze with choreographic analysis. I decided to scrutinize technological future visions from Microsoft and combine the analysis with my dance case study findings. Also this second case had an effect on the selection of the research concepts and the concepts in turn influenced the case (see Laine, et. al., 2008, p.11). I got increasingly interfered with the concepts of intelligent environments, smart objects, pervasive computing, communicating-actuating networks, ubiquitous processing, on-demand data processing etc. This lead to the roots of movement-oriented interaction design theory and gradually my research theory started to make more sense. I was about to reorganize the technological representations of future computer systems from the perspective of material, subjective and embodied user that interacts with the system through his body-in-movement.

The inclusion of a second case within the research changed the nature of the study – at least for a while – from single to multiple-case study. Practical consequence was that I needed to revise my research design. With the new data I had to consider how I would ensure that both cases have a specific purpose within the overall scope of the inquiry as well as logical relation in respect to each other (Yin, 2003, p.46–47). I decided to emphasize the future-orientation in the study and thus new data became dominant in the overall study.

3.2.5 Trials for choreographic analysis

I have spent hours of watching two videos about future interactions that together make around ten minutes of material. My initial understanding of these visions was that their purpose is to inform about the applications of expected future technologies and human-centered interactions enabled by the interface and software designs in the everyday life of the technology users. The analysis following objective inductive trail provided much more difficult than what I had expected. Yet I quantified the data (i.e., counted and visualized the amount of different devices, and grouped interactions in micro, local and macro choreography levels), visualized all interactions of two central characters, documented practically all characters presented in the videos, created customer journey maps for these characters, defined different embodied interaction tactics and wrote about the storyline of these videos I could not grasp the essence of what I was looking after, that was, the effect of these industrial choreographies on the embodied experience, continuum of micro movements and flow of everyday actions.

Only thing I could see was that the characters and the settings presented in the videos were from perfect world where everything succeeded on the first try. This was unacceptable and impossible idea for me since it clearly was far from the reality of human-computer interaction we know today. Three weeks of passionate analysis of these videos has been the most frustrating phase of the entire research. However, this phase thought me that, indeed, case study research is characterized by the use of various data sets and methods, and that the border between the case and the context can be really fuzzy. (see Feagin, et. al., 1991; Sjöberg et. al., 1991; Flyvbjerg, 2001; Stake, 1995; Yin, 2003 in Laine, et. al., 2008, p.10) I also agree with the statement that the case study investigator "should be well versed in a variety of data collection techniques" (Yin, 2003, p.101) because despite the fussiness and friction in the beginning of the third cycle through the multiple methods used I gained lot of insight about the data. I realized the usefulness of the initial data analysis later after I had adopted the idea of dancing as part of the analysis. My early verbalizations helped me to translate some of the new insights emerging in the choreographic practice into language and combine experience of movement with technological and situational characteristics of the interactions. On the other words, I merited my strengthened ability to integrate explicit ideas on the human-computer interaction context associated with tacit knowledge gained during the dancing.

The magical moment in the analysis happened after I had had a presentation in the thesis seminar and received mostly astonishment without very concrete suggestions of following procedures in the analysis. The reaction of my fellow students made me realize that no one really understood what I was studying. Even though I had presented descriptions about movement-oriented interaction design, described the basics of kinesthesia and embodied skills and described basics of the choreographic approach to the seminar, the conversation seemed to concentrate on irrelevant aspects regarding to my interests. My conclusion was that in the original videos (see Productivity future vision, 2009; 2011) there were simply too much objects, fancy environments, and references to cultural meanings, in general, all kind of information that distracted the audience from the essence of movement. Therefore, I decided to isolate the movement from the video and present it as dance choreography (see Industrial choreography). I reasoned that when there is only one "bare body" moving against a plain background the attention would be concentrated to the body and its movement. During the frustrating phases of the analysis I had gained an understanding that it would be impossible to convey this "un-articulated" knowledge related to kinesthetic movement experience to the audience through words. Instead, the industrial choreography and my embodied understanding about it could be performed (see Biagioli, 1995, p.79 in Hoppu, 2014). I got so motivated about the idea that I immediately created a sketch of the choreography and started to practice it. Within three days I internalized the 112 movements extracted from the original videos and practiced writing of daily reflections about the kinesthetic learning process. My initial notes and observations served as a test for this approach and supported the research design of the fourth cycle.

3.2.6 Dancing the case study

Necessary elements of this particular case study research began to piece together with the beginning of dance practice as late as one year after I had started to conduct the study. I organized my theory, practically rewrote theories concerning choreographic approach, smart object logic and the introduction. This was the phase when my research questions started to have a role in conducting the analysis. In general, the central questions in conducting a case study are, for instance, what is the relation between the theory and empiria, what is the representativeness of a case study, and is the relationship between the researcher and the research context objective or participatory (Laine, et. al., 2008, p.14). Furthermore, when conducting a case study the research questions play an important role in specifying what aspects in the case are to be focused. The research questions influence the triangulation between methods and data. When data is triangulated, data is collected from different sources and with different ways, which allows taking the full advantage of using a certain method (Denzin, 1978 in Laine, et. al., 2008, p.24). In this study, information from the Productivity future vision was complemented with my reflections and subjective embodied understanding of the experience of interaction choreographies, an understanding that emerged during the dancing as choreographic practice.

I conducted a one-week intensive dancing phase in the research that was devoted to practicing and writing about the choreography. Each day I danced the sequence five times in the morning. After morning dances I wrote about my ideas on the micro choreographies that made altogether seven entries into my research diary. In the evening I conducted corresponding dance practice with dancing the sequence also five times in total. After the evening practice I wrote about my experiences on the local level choreographies. The result of the evening dances was also seven entries to the research diary. Altogether I have conducted the choreography 70 times. With 112 micro movements in one sequence this means conducting systematically 7840 micro movements. One round took me approximately 2,5 minutes, which means approximately 175 minutes time use in total for active dancing. This is a modest effort when compared in learning any advanced skill, yet it allows an initial analysis of kinesthetic experience of the studied choreographies. The video presents the entire movement sequence and gives indication of the level of embodiment and skill that I reached through practice of performing the choreography (see Industrial choreography).

The ultimate mission of a case study is to make the case understandable (Laine, et. al., 2008, p.31). For this reason I made a tough decision to exclude the Katulavatanssi case study out of the research. It would have been too much work to bring two cases with so little in common into same thesis. Consequently the original aspiration to focus on deepening my knowledge on kinesthesia as a comprehensive movement experience became strengthened. The auditory sensuous dimension and rich variation of situational multisensory experience present in Katulavatanssi remains to be addressed in later studies. Although the decision was hard, a clearer framing made the research focus more crystallized that finally enabled me to operationalize my data and conduct a coherent choreographic analysis.

3.2.7 Generalizability of the case study results

A case study can be conducted for understanding a particular case, for the case's sake, but a case study can also intend to describe or explain certain broader phenomenon. In the latter case the aim is to generalize case study findings in relation to other equivalent cases or in respect to academic disciplinary discussion. Typing of the case study approaches provides a mean to estimate generalizability of the case study in question. (Laine, et. al. 2008, p.31) There are seven different types of case studies: critical, extreme, unique, typical, revealing, future oriented and longitudinal case studies (Gomm, 2000; Flyvbjerg, 2001; Yin, 2003). In this study there are elements of typical and future-oriented case studies.

Technological visions present a typical example on how interaction choreographies in intelligent ICT environment affect the user's movement. This study presents some elementary ideas on the logic how the choreography that is characterized by user-driven use of networked resources and specific form factors unfolds in practice. These findings can be generalized in assessing similar interaction settings and related choreographies. Future-orientation is present in the data since the analyzed Productivity future vision can be considered as a statement of expected technological development. Whether this vision has the potential to indicate actual development cannot be verified. The data is a Microsoft's company vision that is only one among several manufacturing companies and therefore the results of the choreographic analysis should not be generalized too much as an indicator of future development. The generalizability of the future estimations could be strengthened through a comparative analysis of technological visions released by different manufacturing companies. However, this kind of analysis is out of the scope of this research.

The case study findings are most valuable in development and assessment of the choreographic approach to interaction design as a method. Since the method was developed fairly recently – in the year 2013 – it is still in its infancy. The study presents an example of conducting a choreographic analysis based on video material. The study provides information and a case on how interactions between the user and computer system can be analyzed through utilization of phenomenology and hermeneutics of the body in a research application where the researcher's body-in-movement is considered as central instrument for conducting the choreographic analysis.

3.2.8. Shortcomings of the data and research

The research data was consisting of video presentation about human-computer interactions in intelligent environments. The main deficiency regarding data from the perspective of interaction design was that the assortment of augmented feedback strategies presented in interaction scenarios was limited. Only haptic and visual technical displays were presented. Promising area of augmented feedback through auditory displays was totally left out of presentation. In fact, the whole auditory environment was faded by ambient and uninterrupted background music. Also the currently so popular vibrotactile feedback strategies were impossible to spot from the video. The incomplete set of augmented feedback makes that the findings cannot directly be applied in real life environments without considering the interplay of different augmented feedback strategies that do also include auditory feedback.

Another design decision was that scenarios do not present errors neither on the human operator's nor the computer system's side. Regardless the level of technological sophistication and the skill of the individual user, faultless performance will hardly become characteristic to human-computer interaction in the near future. Furthermore, errors are an important part of learning motor tasks (Sigrist, et. al., 2012) and therefore errors would have been beneficial to be presented in this kind of vision. Specific augmented feedback-strategies occurring in the case of human error / computer error would indicate the computer system's readiness to tackle complexities of the everyday interactions and propose solutions for situations when the user's choreography is ambiguous. Examples and solutions for error-correction-strategies within different industrial choreographies and in different interactional settings would be of great benefit for the development of user-end services of the ubiquitous computing web.

Finally I pose self-criticism concerning the application of choreographic analysis in this study. First remark is that the selected data was not optimal in assessing the experience of local level choreography. Living context in a physical real-life space with real users would presumably have performed better in this kind of analysis. My willingness to carry out the local level choreography analysis despite the evident feasibility mismatch between the choreographic analysis and data led to somewhat superficial local level analysis. Instead, the data and selected methods worked well for the micro level choreography analysis, which led to putting a stronger emphasis on this dimension when compared to local level analysis. The macro level choreography analysis, which can be considered as one of the three constitutive levels of choreographic analysis to interaction design, was not included in this study at all. Therefore it is left to the readers to decide whether the study can be hold as a representative example on the application of choreographic analysis, first described by Parviainen, Tuuri and Pirhonen, (2013).

3.3 Method – Choreographic analysis

3.3.1 Introduction to choreographic analysis

Choreographic analysis is an analytic approach that addresses diverse movement dynamics and emphasizes the perspective of embodied and active user. It enables assessment of the interaction choreographies on different temporal and spatial scales. Choreographies serve as utility for shifting the design focus from the shapes and structures of objects on the activity and the intended use of technology. Understanding and expressing the user's movement continuum is a practical way to approach movement-oriented flow of everyday activities. (Parviainen, Tuuri and Pirhonen, 2013) Choreographic approach addresses also such embodied dimensions of experience that can only be accessed by an experiencing body. Therefore choreographic analysis fits well together with research methodologies that approve knowledge of the researcher's body as relevant research material, such as phenomenology (i.e. Hoppu, 2005).

If a study of human-computer interaction identifies only the movements that have direct relevance to the interaction task, the usability and user studies address only a fraction of the movements and mechanisms that influence the interaction before, during and after the use situation. Choreographic analysis ensures that also indirect, yet meaningful movements that emerge in the particular local context of use go through critical design examination. In general, the choreographic analysis should be based on usage of temporal or procedural terms in describing the user's actions. (see Parviainen, Tuuri and Pirhonen, 2013, p.108) Technological developments bring along abstract and complex challenges where the design of the entire organization of systemic information-based activities needs to be defined. There is a risk that the design of physical interactions at the user's end will not be addressed properly. Movement-based interfaces, actions and movements themselves should not be treated as mechanistic means of interaction; this kind of thinking does not support creation of sensitive or intelligent user-centred experiences (Parviainen, Tuuri and Pirhonen, 2013, p.113).

Choreographic approach promises to enhance design of human-technology interfaces that stimulate the imagination of the user with creative movement practices. Designing such interactions necessitate cooperation of experts from technological, cognitive and kinesthetic fields (Parviainen, Tuuri and Pirhonen, 2013, p.113). Understanding and appreciation of embodied nature of movement can be regarded as common denominators for experts coming from different areas of design to work under the choreographic framework. First of all, it is important to understand the user and her way of interacting with the interfaces in a general level. Second, understanding the perception and sensorimotor processes of body-in-movement gives valuable information about how the user's model about her body is involved in the interaction. (compare Ahn, 2005, p.100) Choreography does not refer only to humans but also the movement of objects is to be choreographed through design (Ahn, 2005, p.97).

Meaningfulness and immersion of interaction between the user and a digital device is highly affected by kinesthetic experience of the interaction. On the other words, the user's experience varies depending on her movement, way of handling the objects and responses of the object's material and other physical factors to the user's movements. Additionally, choreographic design approach does not take technological devices and the user out of the environment but, for instance, tablet-computer, the room and a wall can all be conceptualized through choreography. (Parviainen, Tuuri and Pirhonen, 2013, p.109, 113) There is a constant feedback loop between the user and the context. Sensors in the body are functioning continuously and the stream of sensory signals influence ongoing movement that makes it possible for the body to depart from its trajectory as an immediate reaction to subtle changes in the environment. Embodied actions are always directed towards objects relative to the body (Ahn, 2005, p.99).

Ideally choreographic design results as engaging interactions that are, as Rogers (2006) puts it, characterized by the [positive] excitement of interaction (Ibid.). In the worst case interface-centric boundaries conforms the user to kinesthetically mundane and physiologically unnatural choreography that lead to physical problems in repetitive practice. When a product performs pre-programmed interactions with strictly logical means, i.e., button pushes, the users' tasks are broke down into "discrete and sequential chunks" that often means losses in the playfulness and harmoniousness of the product use. The user can also be temporally controlled if the product imposes pre-set timing and order of the user's movements that potentially is in contradiction with the user's own rhythms, capabilities and preferences. (Ahn, 2005, p.97-98) Choreographic analysis has the potential to detect mentioned design flaws and highlight successful choreographic designs related to both individual and inter-subjective interactions.

3.3.2 Spatial scales and scope of the choreographic analysis

Choreographic analysis can be accomplished in three levels of movements. Each refer to a different spatial scale, although, all these levels and scales are interconnected. The levels are labeled as micro, local and macro levels. Micro level movements point dynamicity of "acting-sensing bodies and enactive minds" and the focus is directed to the subtleties and habitations of the user's muscular activity. Spatial focus of the micro level choreographies is the kinesphere, i.e., space within the body's reach. (Parviainen, Tuuri and Pirhonen, 2013, p.110–111) Most of the interactions presented in Productivity future vision (2009; 2011) can be included in the micro level choreography analysis. Different ways of touching, looking, twisting, squeezing, pushing, turning etc. are examples of micro-movements that are considered when conducting the analysis. However, these individual micro movements are not studied individually but micro movements are seen as constituents of a micro-movement sequence. These movement sequences are studied as a whole in relation to the user's body in context.

In the micro level analysis I will assess the kinesthetic feel of the micro movement sequences through the assessment of my own kinesthetic experiences that I gained through dancing the industrial choreography (see Industrial choreography). I will also consider the extent of control that the presented choreographic strategies have on the user's movement. Also an analysis on the mechanisms by which the technology influences the user will be presented. Embodiment of the understanding on the choreographies was sought, first, by appreciating the choreographies kinesthetically through crafting a version of the original movement sequences extracted from Productivity future vision (2009; 2011) into a coherent choreography and translating my personal kinesthetic inner experiences into words. Embodying the technological context was facilitated by thorough study on how the characters move and interact in the original Productivity visions and strengthened by reflections based on technology-related literature. Altogether 112 micro movement interactions were selected from the original videos to be included in the study.

Local level analysis concentrates in how user's engagement is directed to "intentional, environment-oriented and social aspects of interaction" through the choreographic continuum. On the other words, local level analysis intends to define how the flow of technological interactions fits in the user's situations; are the technology uses intuitive and engaging or do they come in the user's way. (Parviainen, Tuuri and Pirhonen, 2013, p.110–111)

Local level choreographies presented in Productivity future vision can be organized by labeling different settings and interaction scenarios. In my collage of the original industrial choreography there are 10 scenarios that enable meaningful local level reflection, i.e. telepresence meeting between office and hotel room (3 people), face to face meeting at the office (2 people), video call between hotel and home (2 people), physical team meeting at the office (4 people), telepresence in a smart classroom (4 people) and meeting at an airport workspace (2 people). In the analysis of local level choreographies I will present my reflections on the interaction choreography as collective technology assisted process. Task-related analysis, namely sending and fetching the information and re-modelling of the data, will be focused when assessing the users' ability to organize information by using the possibilities provided by wireless communications and smart device networks. Spaces as physical structures can also be considered as "moving-oriented spaces and shapes" (Parviainen, Tuuri and Pirhonen, 2013, p.109–110). Consequently the concern how space, technological settings and users' positioning in space will be discussed.

Macro level perspective represents the "socio-cultural effects of the design choices". Systems' level perspective helps to address the question of choreographic sustainability. Geographical as well as virtual space in global scale is considered as the spatial scale related to the macro level choreography. (Parviainen, Tuuri and Pirhonen, 2013, p.110–111) Microsoft's Productivity future visions (2009; 2011) expectedly presented plenty of visions related to computation, on-demand processing and visualization of data, smart supply chain management tools and telepresence meeting solutions, all relevant to macro level choreography analysis. However, due to the kinesthetic analysis being the main focus in this study, and also, the nature of macro choreography examples that mostly presented examples that weight the back-stage computer systems and information processing architecture, macro level choreographies did not allow meaningful entry for embodied assessment. For these reasons, I decided to frame the macro level analysis out of this study.

3.4 Data – Industrial choreography and productivity future vision

The industrial choreography is a collage of choreographic material extracted from the research data, Productivity future visions (2009; 2011), and it includes the most relevant scenarios related to data sending and fetching and real time data and visualization re-modelling. Industrial choreography is foundational part of the data analysis. The focused interactions as well as performance of the key findings of the study are present in its' structuring. The industrial choreography was filmed in Aalto University's television studio through three cameras and on-time editing. In total there were 6 people involved in recording the choreography. It includes 112 micro movements resulting total 150 seconds of dance (see Industrial choreography).

The structuring of the choreography builds on combinations of choreographies from 3 central positions, namely sitting, standing and walking. In the original visions choreographies related to different positions were scattered along the total video material. The reason for organizing the choreographies based on positions was based on an expectation that each position has a strong influence on the possible choreographic strategies. Aligning micro movement sequences based on position thus enabled analysing the influence of a certain position to the variety of possible movement strategies. Another practical reason was that transitions between sitting, standing and walking choreographies enabled creation of smooth movement continuums between different choreographies. This enabled efficient practice and embodiment of the industrial choreography as an entity.

One of the central purposes of documenting the choreography was to visibly state the influence on technological designs and interactive interfaces on the user's body and its movement. Therefore the background was left plain and no effects are used in the realization of the edited version. All the movements presented in the choreography present a movement or a micro-movement sequence related to accomplishing a designed human-computer interaction. The rich variation of different alignments of the body and transitions from a position to another makes the influence of technology on our body and movements visible. During the research process I had showed the original videos to my fellow students but the overwhelming visual representations of different technologies and fancy environments grasped their attention. Therefore I believe that showing first the plain movement without the context is a good way to make the point that technology has a tremendous influence on our bodies. Hence I use this choreography also as an argument to stress the importance of choreographic design because it so fundamentally affects the experience related to interactions in various contexts of everyday life of the users.

Figure 2: Setting for filming the industrial choreography at Aalto University TV-studio / Glen Forde

One of the not so apparent dimensions of the industrial choreography is that it aspires to convey understanding on the movement of visual focuses in space. The Productivity visions focus on augmented visual feedback through technical visual displays that can be situated in different locations in the physical space. During the use situation the user can take advantage of several different visual displays. Switching between displays often causes differences in the user's alignment in space that is a consequence of changing visual focus; when the user fixes a new visual focus she often also turns her head and in many of the examples this influences the whole upper body or pivots the entire body. Initial insights on the consequences of roaming visual focuses on technical displays were found through dancing. This realization led to more in depth analysis of the pathways of visual focuses, visions relation to tactile-haptic commands performed by the user and influence of these variables to the user's choreographies. Since this analysis is pretty technical in nature it is presented in table format in the appendix (see ANALYSIS TABLES). The results of the analysis can be considered as verification on my findings that emerged during dancing. The role of visual and tactile-haptic focuses and their relationships on the user's choreography will be elaborated in the findings section.

3.5 Organization of the data – Scenarios and examples

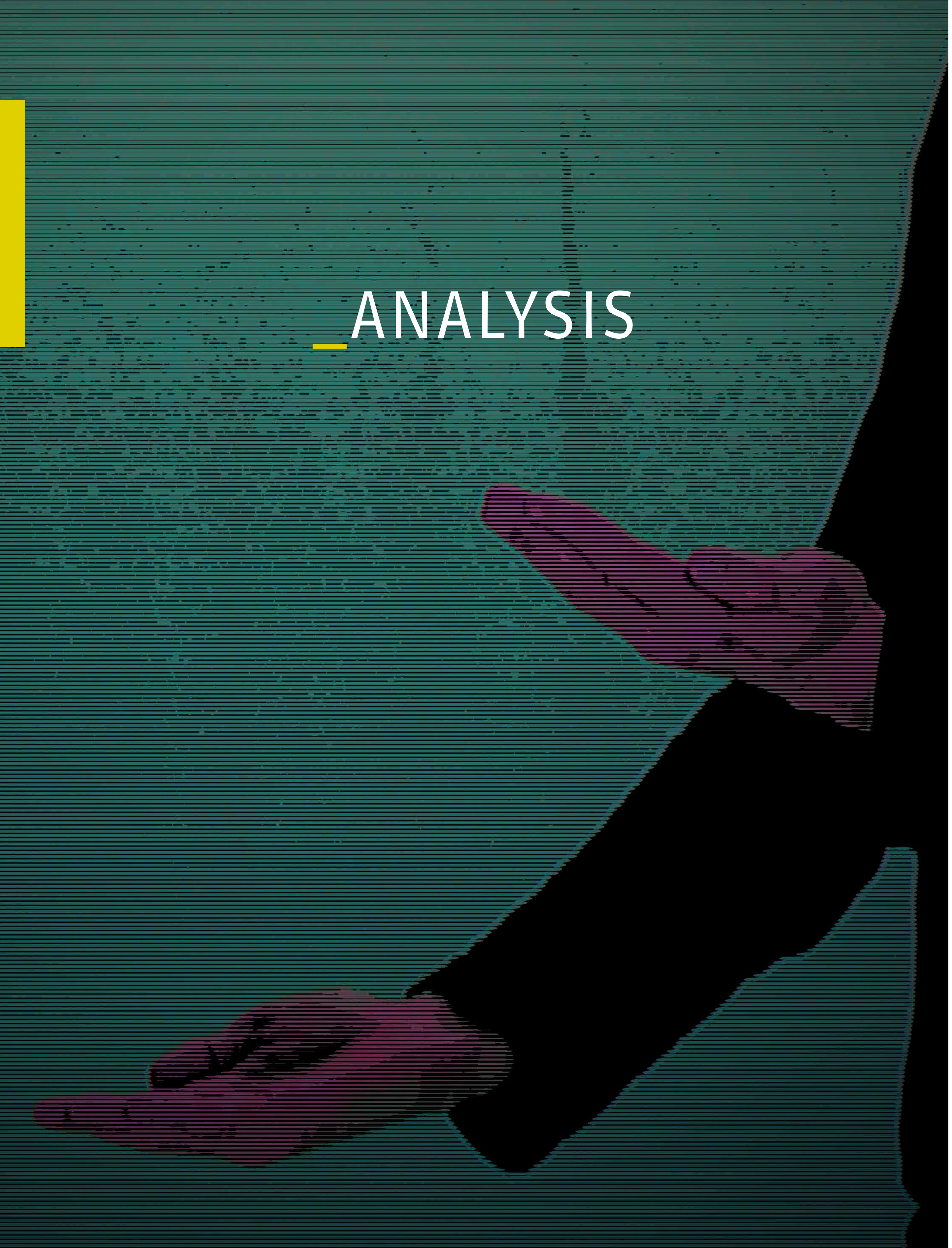
Original data is organized into short interaction sequences that have identifiable themes and that include recognizable tasks. Some of the scenarios contain examples on both studied categories, namely sending and fetching information, and re-modelling data and visualizations. For this reason I decided to organize the data under labels that state to what scenario and what example the piece of analysis refers to. Since there can be several examples on micro and local level choreographies under one scenario I also wanted to differentiate analysed examples of choreographies. In order to do so I marked the examples with running numbers. Altogether there are ten (10) different scenarios and twenty (20) different examples.

Scenarios provide the use context of technology, and an image of the users and their aspirations and needs in the particular interaction context. Therefore the visions influence especially on the local level choreography analysis that addresses also the social context of interaction. In depth description of the story behind these visions would have been purposeless regarding to the overall aim of the study of the kinesthetic dimension of the choreography. Therefore only titles of the scenarios are presented in the attachment (ANALYSIS TABLES). Instead, each scenario is referenced to the original video source and a time frame that indicates where the analysed scenario can be found and it is up to the reader to decide the level of detail s/he wants to familiarize with the scenarios.

Description in the table is technical. It emphasizes practical dimensions of the interaction, for instance, how many users there are, what kind of devices they use and how does the user's sight travel between devices during the interaction. Therefore I recommend the reader to watch the original scenario videos (Productivity future vision (2009); Productivity future vision (2011)) for grasping a visible idea about the social context before reading the analysis. Pictures extracted from the original visions are used in the body text for making it easier for the reader to make a link between the text and original excerpts from the vision.

Scenarios and examples are indicated through abbreviations Sc. for scenario and Ex. for example. Running numbers are used to mark the position of the scenarios and examples based on the order these scenarios and examples are presented in text. The labels will be presented under the picture illustration. The abbreviations [Sc. and Ex.] will be separated with a slash [/]. Example: Scenario 1 and example 1 will be indicated as [Sc. 1 / Ex. 1]. The picture illustration of each example is positioned in the middle of two analysis paragraphs. Other function of the coding system is to serve as a link between the choreographic analysis of the scenarios in the text body and condensed analysis of the examples in the attached table (ANALYSIS TABLES).

The labelling shows that there is one scenario that has five different analysed examples whereas the average of examples is 2. This shows that the scenario 4 that happens in a company office is weighted the most in the analysis. Regarding to the purpose of the analysis this scenario provided the most relevant examples and data sending and fetching, and real time data and visualization re-modelling.



_ANALYSIS

4.1 Sharing and fetching digital content

Sharing digital content such as illustrations, text documents or animations, in real time and based on intuitive interaction choreographies has the potential to significantly improve the work productivity as well as the users' experience. When approached from the user's perspective, access to digital content and ability to move this content around becomes one of the basic interaction needs and one of the most frequently used choreographies in the intelligent ICT environment. Therefore, careful design of micro choreographies related to sharing and fetching digital content is of great importance. Position and variation of this type of choreographic interactions is present in number of examples and different scenarios in the analysed visions (see Productivity future visions, 2009; 2011).

Among all presented interactions there are at least seven kinesthetic ideas of organizing micro movements to perform a document fetching or sending task. The scenarios are situated within an interactional setting consisting of two (or more) devices, the user and the digital content. During the repetitive practice of learning the industrial choreography I have paid attention to the purposes of certain interactions and extracted interesting patterns of movements that are worth crediting and some that deserve criticism. Examples from the visions are complemented by my personal views on possible application areas of presented choreographies. In the micro level, the analysis concentrates on the subtleties and habitations of the user's muscular activity. The kinesphere, i.e., space within the body's reach provides the spatial focus for the analysis. (Parviainen, Tuuri and Pirhonen, 2013, p.110–111)

Local level choreography analysis of future interactions on sharing and fetching digital content reveals strategies how fluent human-computer interaction choreographies save time, improve collective work flow and support interpersonal communication. Three scenarios, namely face to face meeting at the office (2 people), physical team meeting (4 people) and meeting at the airport workspace (2 people) can be analysed through local choreography analysis. Choreographic analysis on local level interaction, in this level of analysis social context of interactions is addressed (see Parviainen, Tuuri and Pirhonen, 2013, p.110-111).

4.1.1 Micro-choreographies for sharing and fetching digital content

First example presents a micro movement interaction of sending a document from a tablet device to a desktop computer. Interaction adopts one-finger drag and drop method and other hand holding the tablet in the right position. The interaction happens between two vertically positioned visual displays. When the user moves his finger on the surface of the device he sees both the movement of his hand and that of the visual content, a diagram in this case, on the screen. When dragging the content to the edge of the screen the content seemingly disappears from the first device and reappears on the second screen. In the use situation the target screen is situated behind the sending screen.

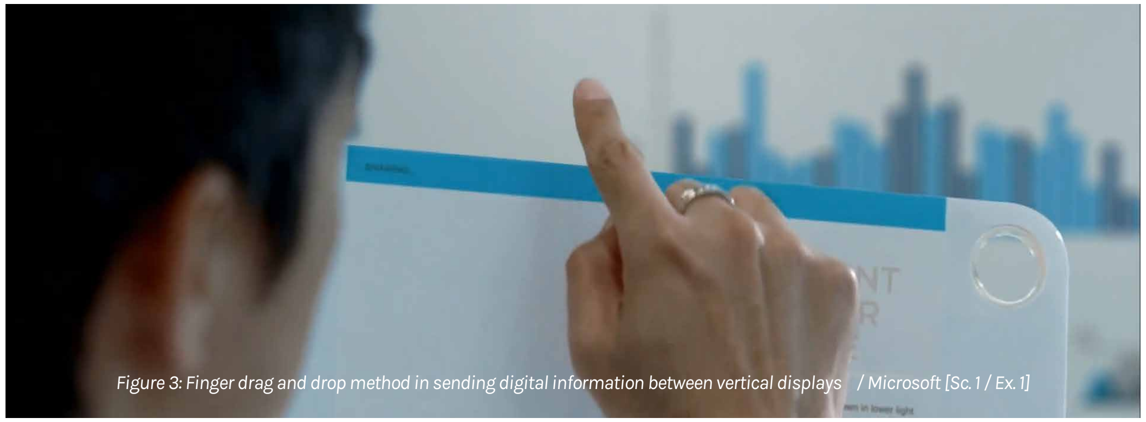


Figure 3: Finger drag and drop method in sending digital information between vertical displays / Microsoft [Sc. 1 / Ex. 1]

Dragging a file can be considered as an intuitive interaction since the user's tactile-haptic-visual sensation provides coherent manifold perceptual response in regard to the on-going task. Learning the possibility of drag and drop interaction can also be learned by accident. For many of the users just understanding the existence of this kind of interaction can lead to the use of these new interactional possibilities. For me it was easy and quick to internalize this interaction in dance practice. I see the application area of this kind of data sharing to be pretty generic between personal devices, such as smartphones and tablets, or between mobile and fixed devices when bigger screen provides advantages in presenting and modifying the data.

Second example presents a data transfer interaction between a tablet computer and a table surface computer. The tablet computer is positioned on top of the table surface computer. Data on the tablet computer's screen is addressed by performing a tapping movement in mid-air on top of the tablet. This movement scales the tablet screen content, an illustration of a recipe ingredients in this case, and this illustration is visualized on top of the device. Zooming and scaling of the visual content happens in relation to the distance between the hand and the tablet on vertical axis. Therefore the illustration can be scaled dynamically through hand gestures. The user can move the data through using her palm. When the illustration reaches the border of the tablet border the illustration is produced in collaboration between the tablet and table surface computer screen so that the illustration remains seamless. The wider table-surface-computer provides a larger screen that supports extending the illustration into a form that supports cooking the pastry described in the recipe. "Dropping" and spreading the information to the table surface computer happens by movement of extending out the fingers.

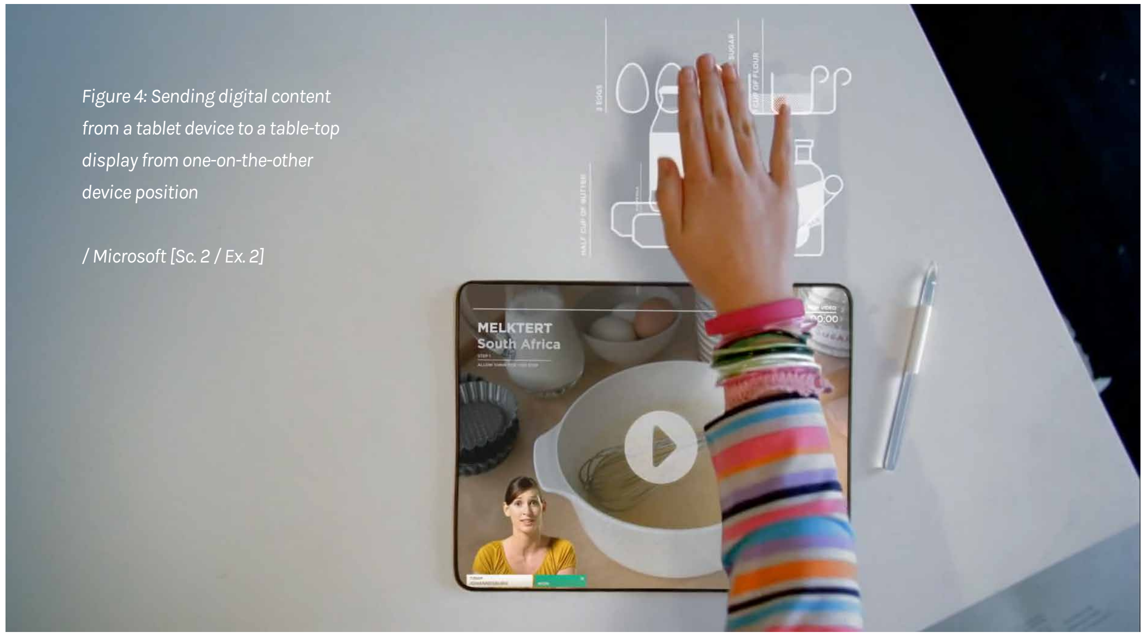


Figure 4: Sending digital content from a tablet device to a table-top display from one-on-the-other device position

/ Microsoft [Sc. 2 / Ex. 2]

I felt this kinesthetic experience of this micro movement sequence pleasurable; especially tapping as a method for drawing data out from the device was a fun idea to me which resembled the act of tapping a floating object under water surface and waiting for the following pop up on the surface level. I relate this particular interaction with the (Rogers, 2006) recommendation of designing human-computer interaction on the basis of the "excitement of interaction". This interaction is handy when two smart objects are on top of other, for instance, when a smartphone is on a smart table surface and the content from the screens are shared between the devices. The feature that scales the images spares the user from lifting up the device, using menus and tapping or clicking selections directly to the device. This movement sequence needs the user's body to know the interaction. The potential of replacing a series of routine manual operation with a shorter and inspiring movement sequence deserves positive credit.

In the third example the user holds his left hand in a pointing position and directs the information content on a computer screen. Through using his other hand the user drags the content from the computer to a tablet device. Visualization of the data in a form of screenshot image is projected on top of the seamless computer-table graphical user interface. This provides concurrent visual feedback for the user that complements internal haptic feedback of his performance and informs about the progression of transferring the file. This strategy is based on the user's knowledge of existence of the interaction strategy and mastering technique for accomplishing this gesture command in data transfer. The knowledge and skill requirements make the third choreographic strategy pretty hard for the user to figure out by accident.

Figure 5: Fetching information from a personal work station to a tablet device through gesture commands / Microsoft [Sc. 3 / Ex. 3]

Kinesthetically this choreographic strategy feels logical. Furthermore, I can see various application areas when interacting with visual interfaces, for instance, transferring a TV-program from the wall-screen to one's personal device or selecting a texture from an interior design catalogue of a tablet-computer and then performing this command to change electrical room decorations individually through pointing furniture, a textile or a wall with locating hand gestures. The wide application of the basic idea of this gesture command can be seen to stimulate the imagination of the user with its creative movement practice (see Parviainen, Tuuri and Pirhonen, 2013, p.113).

In the fourth example a small handheld pen-shaped object is used for touching and selecting digital items on a smart screen. Directive quick movements are used to send the selected information package to the screen of a smart wall surface computer. Pen-shaped objects were used several times in the vision in conducting this data-sending task over a short distance. Also a finger could send data over a short distance through a quick directive sweep. The hand movement's directedness towards a proximate visual goal together with speed of the movement similar to casting small objects over a distance can be seen to make a natural analogy to human-object interaction in a real world, for example casting a little stone.

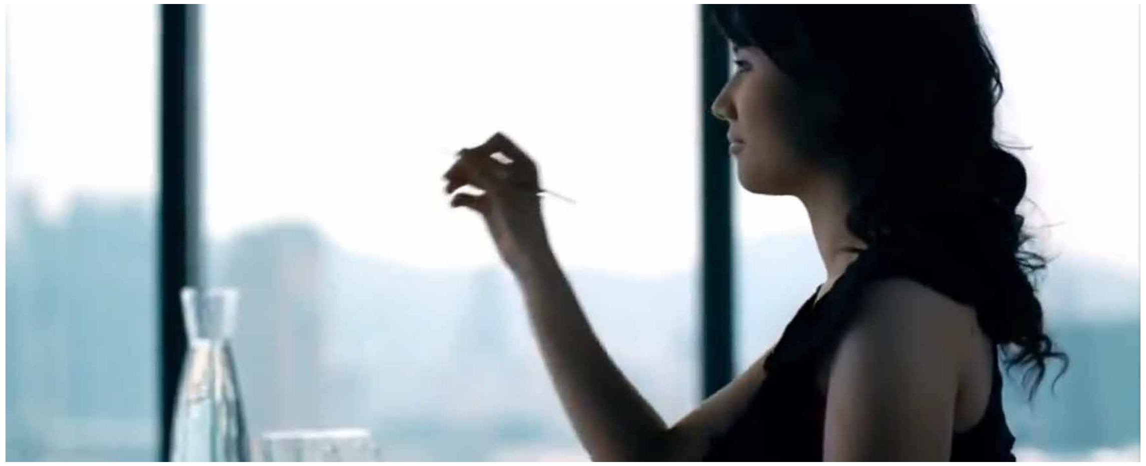


Figure 6: Sending information from a table-top display to a wall display using tap by a pen / Microsoft [Sc. 4 / Ex. 4]

Because of the natural analogy, this micro movement is intuitive and as such I agree with suggesting this kind of micro movement interaction. Practical uses of sending information through micro movements or through piecing smart devices together could be, for instance, tapping a fridge door with a smart grocery package to have product information in a more readable form on the smart fridge surface screen or to touch a tablet Internet search application with a smart book in order to seek books of similar kinds, or to touch a radio with your personal music player to fetch the currently playing song to your playlist.

The fifth example introduces usage of a smart object as a remote controller to catch and transfer data between two devices, namely a wall-mounted display and a tabloid-sized electronic paper sheet. In this movement sequence the use of a third device and operation of the device manual is an extra step compared to many of the previous interaction choreographies. It is noticeable that when information is fetched from a device over a distance the computer might need more detailed description of the user's aim than when merely selecting and sending information to a certain direction. One example of fetching information with a smart object follows a path where selection of a file is accomplished through using the smart object as a remote controller, next the document is "photographed" and, finally, the document is moved to the final device through tapping the devices together or, alternatively, performing a data transfer by a finger swipe command.

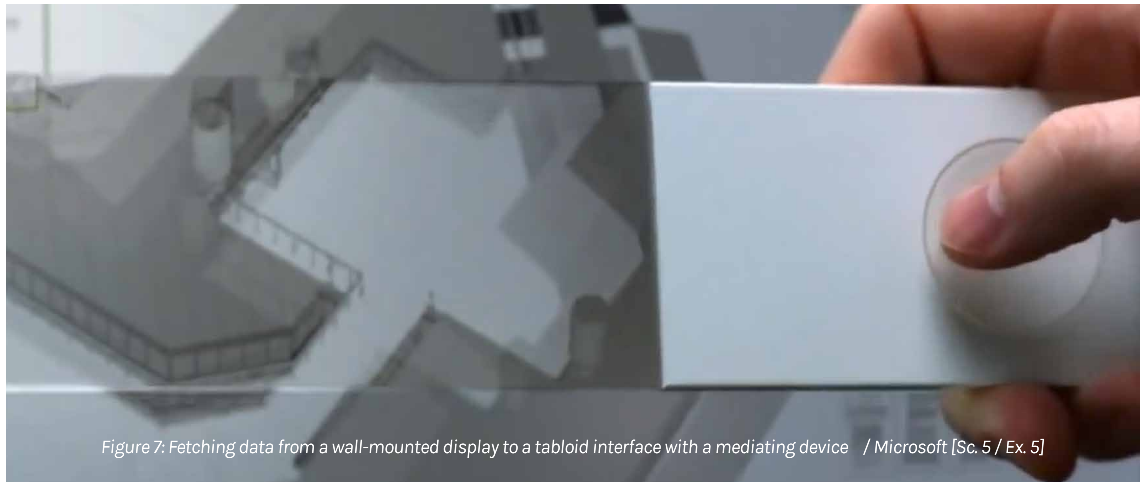


Figure 7: Fetching data from a wall-mounted display to a tabloid interface with a mediating device / Microsoft [Sc. 5 / Ex. 5]

This kind of interaction was not kinesthetically as cumbersome as this written description might suggest. Also, the document-fetching over a distance could be used more widely in collective spaces, such as schools and museums, where information about teacher's exercises, information or interactive content could be sought to the users' own devices. This could have diminishing impact on disturbance caused to other people in the same space by individual actions. However, attention should be paid that designed choreography is not mere a continuum of discrete and sequential chunks that lead to losses in the playfulness and harmoniousness of the interaction (see Ahn 2005, p.97–98) but that the interaction unfolds taking advantage of the context and situation of use. In this example the electrical paper enabled the user to inspect a map illustration in much more meaningful and kinesthetically natural way than the wall-mounted display would have had enabled him to do.

Sixth example is based on split-screen smartphone and different apps running on these screens. The example shows a scenario where a person is heading to a meeting within a new environment. His smartphone knows the location of the other person and therefore video-call communication and way-finding can be combined within the same interaction sequence. The command from the way-finding app that basically is a combination of a map and user tracking application is linked with the location data of the other person that is accessed through the contact information menu. Way-finding support is then given through a holograph augmentation. It is likely that this information is to be augmented to the user's smart glasses since the glasses' possibilities were presented slightly before this way-finding episode. However, the video does not state this clearly.

Figure 8: Servicing way-finding and communication application with a split-screen smartphone / Microsoft [Sc. 6 / Ex. 6]

It might occur from the description that too many things are tried to achieve at the same time. Kinesthetically the experience of trying to use the split-screen smartphone while simultaneously operating two applications leads to a pretty unnatural somatic experience. Nevertheless, the map application has a feature to zoom the map in response to vertical level alterations of the smartphone screen and show larger areas of the map when the user moves the screen horizontally. This feature was among my favourites due to the brilliant combination of a pleasing movement experience and innovativeness of data processing application. These kinds of applications enable dynamic exploration of a map from a small-screen device without hindrance of using two hands, sweeps and two or three-finger zoom commands without compromising the usability of the application.

Seventh example was realized simply by putting two smart objects on a smart table screen that allows the devices to network. Both of the personal devices contain the users' personal information. Unlocking the device(s) was realized through fingerprint recognition that opened up information related to the communication history between the device owners. Also this strategy takes advantage of the smart object's ability to create ad hoc networks, in this case triggered by the devices' positioning on top of a third-party table surface display where data sharing and interaction can be realized in various ways.

Figure 9: Biometric identification in sharing personal documents on a publicly available table-top display

/ Microsoft [Sc. 7 / Ex. 7]

All in all in the scene presented after unlocking the device through fingerprint recognition remained pretty vague and did not transfer a convincing vision about how the smoothness and efficiency of this kind of micro choreographic interactions could be like.

4.1.2 Local level choreographies for sharing and fetching digital content

The eighth example presents information sharing between a tablet device and a desktop computer at an office space. In this pretty short scene the visiting person presents numeric data to his partner. The data has a pillar diagram layout. The visitor's data complements the similar kind of data on the desktop computer screen. Tablet interface is used to show the data to the colleague and, after mutual approval, the two data sets are combined. The data integration happens by dragging the diagram off the tablet border and 'dropping' the information to the desktop screen behind the tablet. The transfer happens between two vertical screens.

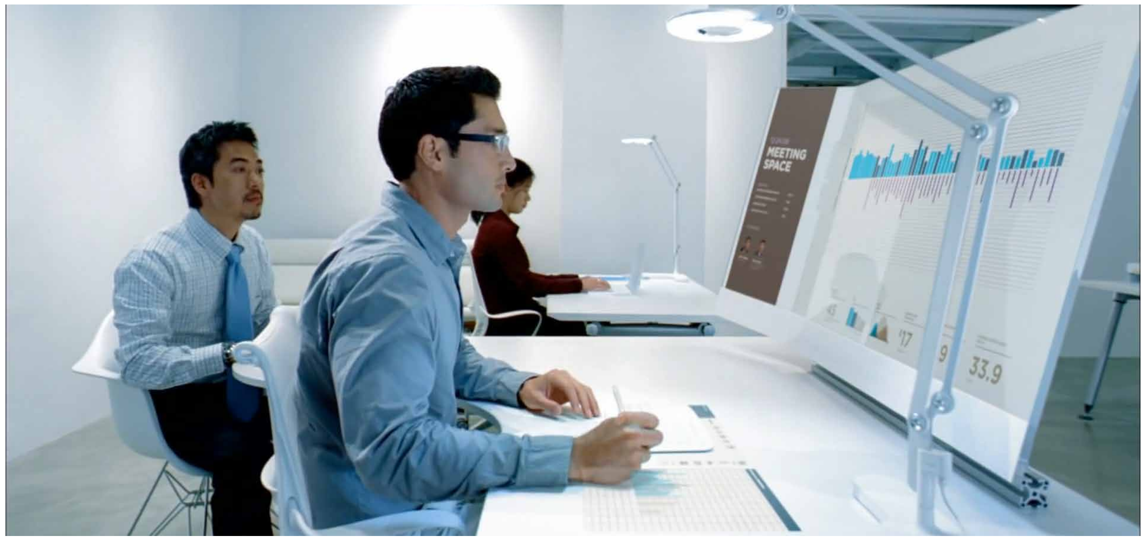


Figure 10: Finger drag-and drop method in data sharing supports mutual collaboration and shared project ownership / Microsoft [Sc. 1 / Ex. 8]

The factor influencing the most to the social choreography is that the data sender can make changes on the data layout through his own tablet also after sending the data. This functionality supports the collaborative workflow since both experts can keep on working with the data. Additionally, interacting with a personal device is most likely convenient to both of the users. This is an advantage when compared to a situation where one of the experts would have needed to work with unfamiliar device if he would have wanted to make some further adjustments to the data. At this scenario both of the interfaces seem to support the continuum of the micro-movements but especially the choreographic design that enables the visitor's use of the interface familiar to him is of great benefit. Even though the same applications would run on the other devices and interaction logic would remain the same, personal device has a personal feel on it that plays a big role in the user's experience of interaction.

Example nine presents an interaction that has significance to the entire project team's process. An employee shares data generated in the previous meeting to the team on a wall surface computer interface. These materials include documents such as digital post-it mind-maps. The secretary shares post it shaped project data from a smart table-top-surface to the smart wall in the meeting space.

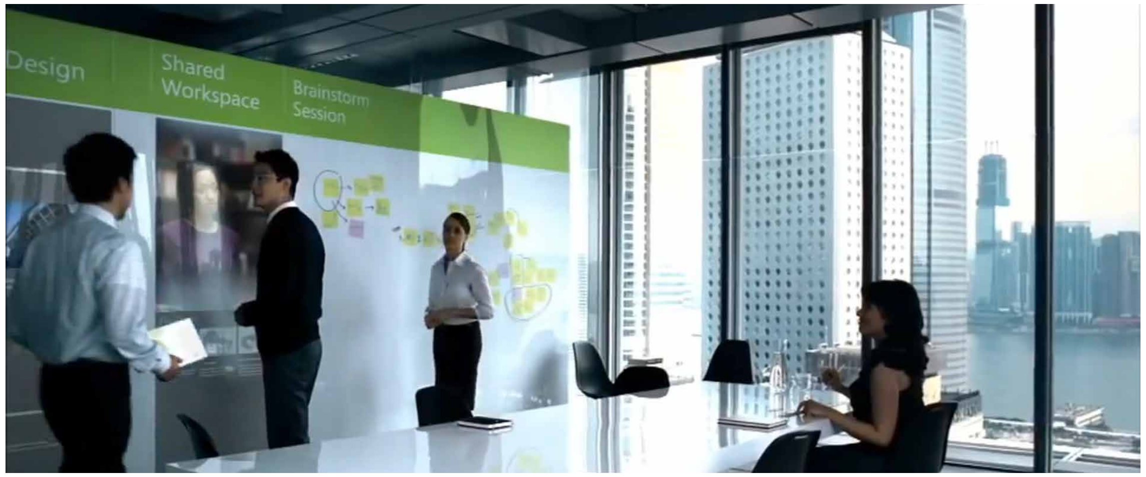


Figure 11: Dynamic networking of interactive elements and personal devices supports the fluency of collective choreography / Microsoft [Sc. 4 / Ex. 9]

The data is probably in the same format it was left after the latest meeting. From the kinesthetic perspective the physical arranging of information is a result of the team's embodied processing of information. Thus the ability to present the image of the data according to how post-it notes were physically organized in a collective process has the potential to refresh the body-memories related to previous meeting(s). Another advantage with the digital format is that it enables the open space to be used for other purposes in between of the meetings without the need of retaining the data physically on the wall. It would be challenging to find solutions of keeping project data in post it format safe, for example on a meeting room wall, for nearly any organization. Therefore, the digital visual presentation of previous collective work is useful in creating a continuum of movement that exceeds over the time and location of the current meeting. Wall surface display enables the traditional choreography of working with post-its that can be regarded as positive example of adopting choreography from traditional workflow into the context of intelligent ICT environment.

Tenth example introduces choreographies that are pretty vague; the most visibility is given to the pre-programmed visual animations generated by a table surface computer and thus the role of the users in actual human-computer interaction remains marginal. Nevertheless, the position of the table-top-interface supports standing position, coffee drinking and face-to-face conversation of the characters while working with the information. Therefore the physical setting for human-computer interaction can be seen to support other social activities, such as natural interaction and collaborative working. From this perspective the meeting in public airport work space is a refreshing example of how technological interactions can be designed so that they do not come into the way of natural human communication.

Figure 12: Table-top-surface functions as mediating interface between the users' devices and enables face-to-face presence / Microsoft [Sc. 7 / Ex. 10]

4.2 Choreographies for modelling data and visualizations

The promise of ubiquitous computing web is not only based on the access of ready-made visualizations of data but also the ability to interact with the data visualizations and modify them in real time. Especially the increasing support of ubiquitous data processing and visualization middleware services enables the data to become increasingly useful for end-user service development (see Gubbi, et. al., 2013, p.1649–1651). Emergence of agile human-computer interaction choreographies for the interaction with the re-modelling data and visualizations is a necessity if we want to capitalize the potential of sophisticated inquiries and on-demand data processing. In intersubjective interaction setting, the complexity in creating useful and engaging interaction choreographies increases.

In the analysed interaction visions there are at least six ideas about micro choreographies that describe real-time on-demand data and / or visualization modelling. These choreographies are important in the future intelligent work, education, leisure and transportation environments. Since the amount of information is expected to increase dramatically, the ability to communicate essential information effectively will become a key competence of professional service organizations as well as a practical know-how for individuals in organizing the flow of social information in everyday personal communications.

Micro level analysis looks into the intuitiveness and experience of kinesthetic micro movement continuums and this analysis is used to suggest application areas of presented interactions. Local level analysis looks into situations where on-demand data visualization is applied in dynamic and participatory process where several participants manipulate the data in a collaborative setting. Multi-user situation causes significant challenges for computer systems that need to recognize and distinguish the meaning of the input of each individual participant. The spatial distribution of the participants, the positions of technical displays and the availability of smart objects to interact with the visualization becomes fundamental design aspects that define the success of the interactional setting. All the micro choreographies, except the fourth and sixth scenarios, suit also for meaningful local level choreography

analysis. The fourth choreography is excluded because it did not present a clear social context and the sixth choreography is excluded because of its unrealistic nature.

4.2.1 Micro choreographies for modelling data and visualizations

In the eleventh example schoolchildren communicate through a smart telepresence window interface in a classroom. The window interface is placed as a traditional blackboard. A kid draws a dog on the screen and complements the drawing with a ball. Through top-down sweep on the ball's surface the kid imposes the object under the force of gravity. A sequence of vertical top-down movement and a lateral hand gesture the kid sets the ball in motion. Simultaneously the dog runs after the ball to another end of the smart window screen interface. In this example motion graphics are generated on-demand in the use situation.

Figure 13: Motion graphics are generated on a wall-mounted display by drawing with fingers and animated through gestures / Microsoft [Sc. 8 / Ex. 11]

Kinesthetically I felt the experience of drawing a ball and sending it into motion pleasing and easy. The movement sequence combines circular and straight movements. The sweep to cast the ball activates the whole upper torso. The user may also exaggerate this final movement without compromising the computer-recognition of the user's intention. Therefore this movement sequence is pretty open ended and stands out among many other more restrictive micro movement choreographies. The ability to influence on animated object with my own movement is inspiring since this kind of an interaction blurs the boundary between the computer-generated digital world and lived world experience. Especially the dog's movement gives an external kinesthetic impulse for those watching the dog. The interfaces for concurrent motion graphic processing could be excellent in education, for example in teaching the principles of kinematics, drawing illustrative pictures or sensitizing to the different movement styles of different animate or inanimate bodies. Motion graphics can also have application possibilities in home decoration and animating lived spaces, including the public spaces for leisure and wellbeing.

The twelfth example showcases a specialized professional information modelling interaction on a wall surface computer interface. The purpose of the model is to illustrate natural lighting conditions and available solar light energy on a rooftop during different times of the day. The building model and its position, trajectory of the sun, shadows made by the building, among other characters in the model, are taken into account and visualized as a dynamic graph. The graph and its operating interface are projected on a smart wall surface. The user controls the graph through a circular user interface with a clockwise or counter clockwise movement which affects the light and shadow patterns generated through the position of the Sun. The interface is a good example of the usage of concurrent visual information (see Sigrist, et. al., p.25–30).

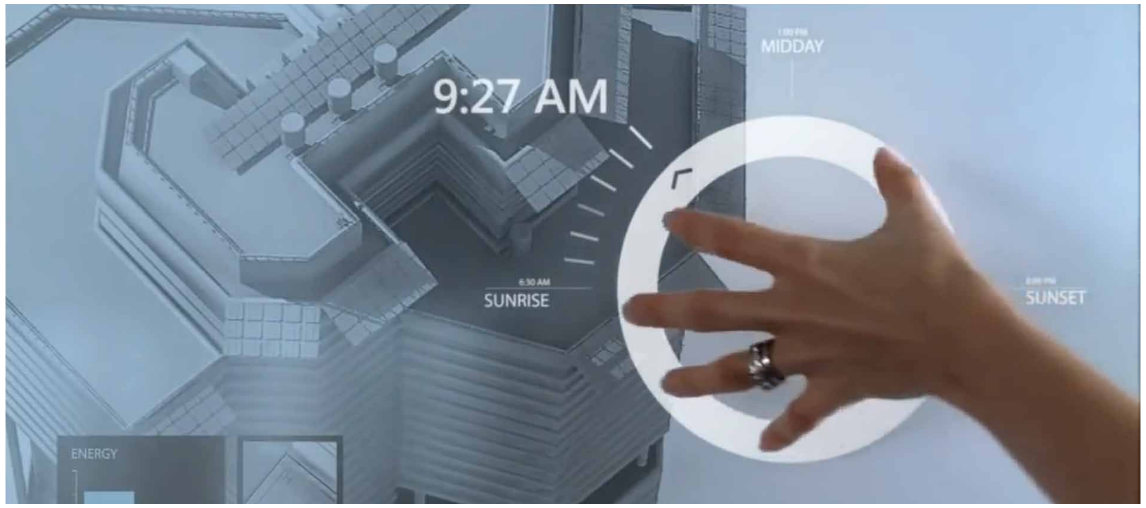


Figure 14: Dynamic information modelling tool on light and energy availability on a rooftop / Microsoft [Sc. 4 / Ex. 12]

I consider this interaction as an example of kinesthetically insightful micro movement choreography. The movement of the sun is perceived as arch-shaped trajectory and therefore the micro-movement choreography on a vertical wall surface together with visualization makes an analogy to the natural experience of the movement of the Sun. Circular interfaces are widely used in many applications, such as volume and light controls, locks and timers. In future, this traditional interface can be adopted in cleverly made applications for data visualization related to routine tasks within knowledge intensive business. Applications can become increasingly tailor made for the needs of the specific company. Dynamic lighting visualization on a rooftop gives a prominent example of the advantages this kind of applications can offer.

Thirteenth example shows dynamic scalability of a construction model, this time in a choreography consisting of the user, a tablet computer and wall surface interface. Scenario presents how an illustration of a cross-section on rooftop garden construction can be adjusted so that the illustration is easier for the audience to understand. In order to adjust the illustration the user rotates a little round control button by a clockwise movement that leads to alienation of the layers in the model. This rotational movement resembles distantly from operating a crank handle, yet the movement is miniature in size when compared to often quite large diameter rotations of a crank handle. As such, the design can be seen to look into direction of mediating interface that "fuses with the sensorimotor schemas of natural interaction" (Parviainen, Tuuri and Pirhonen, 2013, p.105).

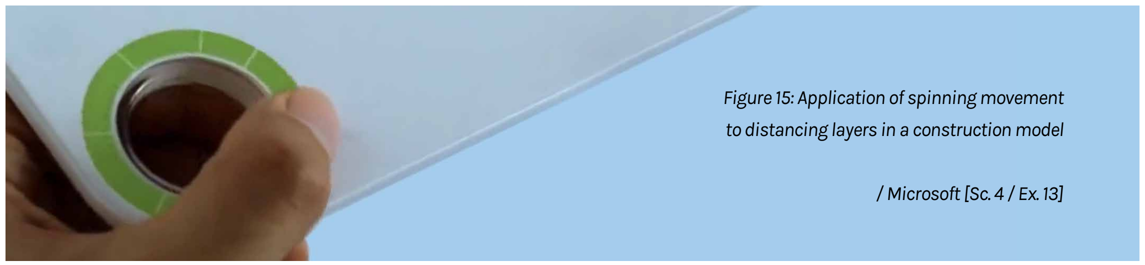


Figure 15: Application of spinning movement to distancing layers in a construction model

/ Microsoft [Sc. 4 / Ex. 13]

The physical idea of operating a "crank" pulling the visualization layers apart can serve as a natural kinesthetic metaphor for this specific micro choreography. Nevertheless, I did not find this particular interaction pleasing since it was included in a movement sequence with lot of switches between hands holding a tablet computer in order to operate the device from the right end with the right hand. For me it felt that unnecessary movements needed for balancing with the device when operating it could be replaced with a movement sequence where each of the interactions would be directed towards the purpose of the activity. This note highlights that a single clever micro movement idea can be lost in a clumsy movement sequence. Therefore attention should be paid to designing clever micro-motor interactions that together form apt movement continuums.

Fourteenth example presented manipulation of a chart that, presumably, describe properties and selection of the materials for a specific construction site. The interaction unfolds around a desktop computer of an individual employee at his office. Operating the computer is accomplished through a graphic round selection panel with a touch screen situated on the workstation table surface. This scenario is one of the many belonging to the product category that seems to be built on the promises of transparent circuit technologies. The choreography is very restricting. Round selection interface is positioning the user's hand in an exact location (as opposed to traditional physical mouse interface). The graphic user interface is changing along each selection and this increases the complexity of the interaction. Although concurrent visual feedback is applied that, in principle, has the potential to decrease cognitive load since "it attracts an external focus of attention" (Wulf, 2007 in Sigrist, et. al., 2012, p.26) in this case the continuously changing interface can be seen rather to overwhelm the user.

Figure 16: Manipulating graphs through stable touch-screen interfaces may lead to unhealthy choreography in extended use / Microsoft [Sc. 3 / Ex. 14]

The actual manipulation of the diagram containing the information on material properties is accomplished through pushing and extending a pillar in a diagram that emerges beside the round selection interface. The interaction in itself, in my opinion, is inconsiderate and does not support a healthy micro-movement continuum nor represent an intuitive cognitive design.

Fifteenth example is mostly about a strategy that supports the use of micro movements in accessing different layers of information on a smart phone screen without using traditional operation tactics, such as touching and sweeping the screen. The scenario presents an interactive marketing screen that can be communicated with when the connection is first established through pointing a marketing screen with personal smartphone camera. The figure presents a campaign in favour of collecting money for realization of ethnic concert. The donation is given through a simple touch on the pre-defined selection menu showing different sums. The information that follows shows the distribution of different donations by donation size and distribution of given donations between all the campaign locations in the network of the city's subway stations. The information is presented in a three dimensional pillar diagram format and the user can move between these two visualizations through balancing the device from one side to another.

Figure 17: Viewing statistical data; tilts combined with dynamic shadows and 3D-impression via personal hand-held device / Microsoft [Sc. 9 / Ex. 15]

The resulting interaction is kinesthetically extremely logical since along the change of the graph the shadows are created to the side of the tilt. Therefore the visual processing of the image can easily be associated with haptic-tactile proprioceptive feedback that results of the device use. For me this interaction would be a reason in itself to play with the feature and simultaneously look at the content. Therefore a good kinesthetic design can strongly support the communication in, for example, marketing but the most important applications may be found in communicating data in the areas of health, transportation, education and entertainment.

Sixteenth example presents complicated data processing through gesture control in a telepresence meeting that unfolds in choreography between two people, a desktop computer, table surface computer, smart pen and a wall-mounted display. Gesture commands are widely used in addressing the computer system. It remains unclear to me what is the logic of the entire choreographic sequence. The sequence starts from a 3D-holograph statistical information, which is then transferred into geographical map-based visualization through keyboard commands, next, an area of statistical information extracted from the map describing the selected surface area on African territory is activated by a two-hand gesture-command, then, this data is transferred into a pillar diagram format through a grasping movement on a smart table top screen, which turns the data into a holograph 3D-shape and, this information is again thrown back into 2D through a sweeping hand gesture in mid-air and, finally, the pillars are adjusted with a two-hand gesture supported by a smart pen-shaped object.

Figure 18: Complicated productivity-oriented statistics modelling may compromise the experience of micro-movement sequence

/ Microsoft [Sc. 10 / Ex. 16]

This micro choreography is realized in reciprocal interaction of two people. Micro choreographies of this complexity can be compared to learning a complicated group dance pattern with the computer being the third party. If this kind of complicated choreography is even slightly departing from the very routine of the organization, it will be very challenging to remember all the required interactions. What is more, the two-hand choreography for framing the area on the map did not feel good. If stretching arms towards the side and performing a converging movement is felt hard for a young man like me it will most likely be it for the majority of the users. Therefore I will take this micro choreographic continuum as a warning example of a bad and detrimental industrial choreography which should be avoided with means of prototyping the movements (and maybe testing them in a living-lab-type setting in a specific market niche) before the introduction of such compelling interactions to the great public.

4.2.2 Local level choreographies for modelling data and visualizations

Seventeenth example elaborates the interactions between the pupils and smart wall interface in the classroom. The example presents an intelligent classroom telepresence solution that provides simultaneous translation and motion graphic processing. I consider these services as a powerful set of tools to be used in intercultural communication. Position where the children face each other in a touching distance creates a basis for personal intimate communication. The experience of presence is convincing since the graphical interface between the children provides sharp and realistic imaging on the other person and the context where the person is situated in.

Figure 19: Dynamic interfaces can bring advantages in explorative teaching of kinematics and in stimulating the class / Microsoft [Sc. 8 / Ex. 17]

The children, their postures and facial expressions and voices are in the central role in communication. Other features, such as motion graphics, are part of the interaction affordance provided by the technological setting. These resources are mostly utilized based on the user's initiative when the interaction provides extra value for the communication itself. It seems that this interaction is not so much about controlling the user but rather "extending and supporting personal, cognitive and social processes" (Rogers 2006, p.406). Furthermore, the technology has been designed for the particular context, the school and classroom environment in such a way that enables the other children to carry on traditional classroom activities. In the meanwhile a few children can immerse with the intercultural interaction.

Eighteenth example introduced rooftop visualization as an instantaneous micro interaction within a team meeting by a smart wall surface interface. What is noticeable here is that the meeting was organized around a smart wall that served as the central piece in the interpersonal visual communication. The light visualization information element, among others, was used in communicating the necessary information for managing the rooftop garden design process. The visibility to the visualizations and easy user interface made it possible for the closest person to manipulate the graph. Socially this kind of easy-to-use interface can function in favour of equalizing the group process. My argument on this application's potential in supporting equality in the team's work is that the person holding professional expertise in light information modelling is not presenting this information from her personal computer. Instead, the end result is accessible for the team through an easy-to-use application that is presented to the whole team as an interactive element constantly present on the wall surface interface. Thus, the interaction setting and choreography supports equal agency for all team members in respect to the data.

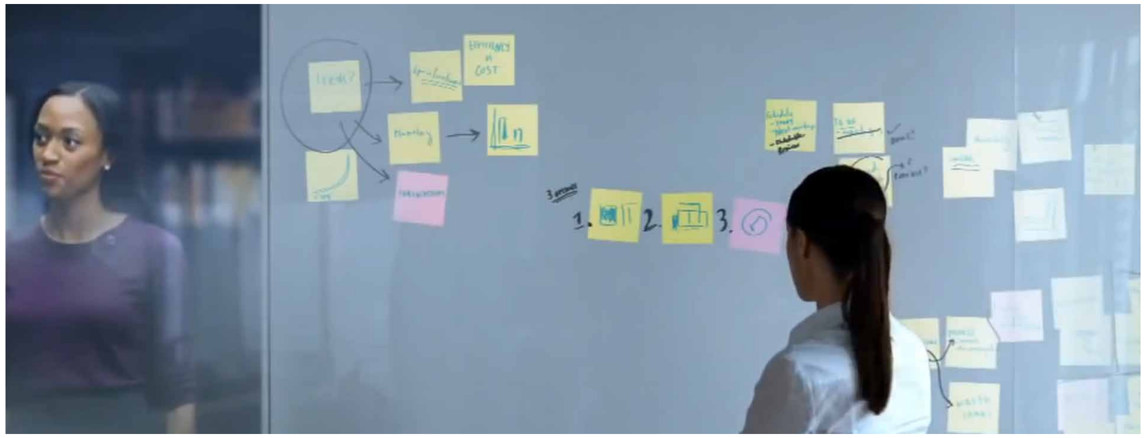


Figure 20: Archiving and re-modelling co-designed data can facilitate collaboration and upkeep process awareness / Microsoft [Sc. 4 / Ex. 18]

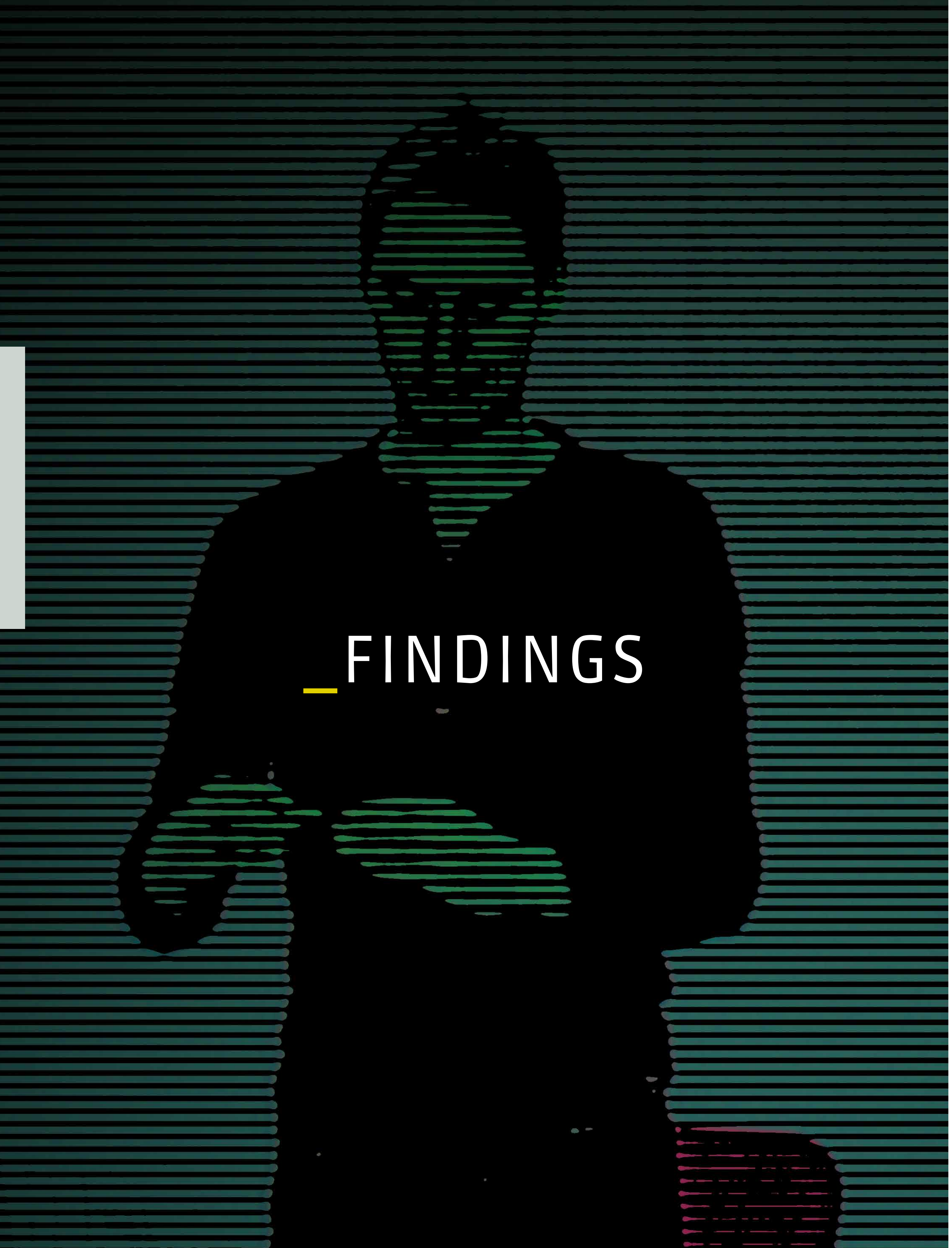
This kind of choreography can strengthen the feeling of shared project ownership and create a natural collaboration over professional boundaries in the overall working protocol. Naturally the holistic understanding of the workflow and context needs to be acquired when analysing the influence of a set of used applications for the entire local level choreography. The project needs of professional design and engineering office is a topic way too complex to be "de-coded" from a short video clip in order to reconstruct a full image of local level choreography. Altogether, this example reminds about the possibility to consider intelligent environments as "moving-oriented spaces and shapes" (see Parviainen, Tuuri and Pirhonen, 2013, p.109-110) On the other words, purposeful choreography is characterized by a workflow where the space, the user and digital resources are all taken into consideration and the integration of these elements constitute the eventual, meaningful and procedural interaction choreography. In my opinion, this example gives many promising ideas about integration of the embodied action and intelligent interactive setting characterized by elements that have been designed in respect to each other.

Nineteenth example belongs to the same scenario with the previous example. The central difference is that the designer arrives with newly designed information that is then shared with the project team. The information is presented and manipulated to more user-friendly format by alienating building construction model layers. However, the scenario does not show what the role of this information is to the group process. Therefore it remains unclear whether this feature supports the movement continuum of the social process of designing together within this particular company and at this particular meeting.

Twentieth example presents a scenario of interacting with a marketing screen powered with artificial intelligence. The interaction is situated in public space, on a subway station, where people waiting for a car can supposedly spend time with interactive marketing. Nevertheless, this advertisement is not invasive but leaves the initiative to the user. On the other words, the technology is not intruding to the user's personal space through sending messages to the personal devices.

Figure 21: Ad hoc device networks can support introduction of personalized marketing in public spaces / Microsoft [Sc. 9 / Ex. 20]

The interaction itself is nicely crafted. The naturally perceived communication with eye contact, body posture towards the user and empathic spatial expressions is all included in this social choreography. The social movement continuum of the user has natural pauses when waiting something or someone or just relaxing that might well accommodate local level interactions that are specifically designed for these calm pools in the flow of everyday events and interactions of a user.



5.1. Emphasis on user-centred choreographies

The obvious research finding based on the data analysis is that choreographic design has been prioritized in the design process of the Productivity future vision (2009; 2011) and that the visions have been crafted through extremely user-centred way. Technology users and their interaction choreographies occupy the central stage in every scene presented in the videos. Setting the user's body and its movement in the focus of a company vision is a strong indicator that in Microsoft the benefits of the future Internet is believed to be best harnessed through seamless integration of the user's body-in-movement and the intelligent ICT environment. Furthermore, choreographic design and innovation are considered as valuable tools for making the Productivity future vision to happen. The vision presents a serious trial to accomplish ideal of a human-computer-unity through choreographic designs that reach for natural interaction. Therefore the vision can be seen to adopt many ethical and practical standpoints presented in the choreographic approach described by Parviainen, Tuuri and Pirhonen, (2013).

More ambiguous yet relevant interpretation based on the Productivity future visions is related to the choices on how individual users are presented in the visions. In all of the scenarios the users are seemingly calm and I interpret their facial expressions to convey messages of pleasing bodily felt qualities of the interaction. In the vision, natural choreographic continuums are suggested to enable the user to accomplish technological interactions as smoothly as any other routine everyday actions. Vision presents rich variation of choreographic strategies that have been created in order to avoid interactions with strictly logical means, i.e., button pushes where the users' tasks are broke down into coerced and strained micro movement continuum that may contradict the user's own rhythms, capabilities and preferences (compare Ahn, 2005, p.97–98). Regardless some choreographic flaws and naive visualization of the end result the productivity vision provides an example of a fair effort to promote choreographic innovation in intelligent ICT environment design.

The argument of Microsoft giving high priority to choreographic design in the visions can be backed through depicting the systematic principles that both of the videos that consist the vision (Productivity future vision 2009; 2011) are designed with. When I constructed my re-composition of the movement material based on screenshots taken from the original visions and I was able to extract a complete movement sequence in each of the scenarios. This cannot be coincidence but shows empirical evidence on resoluteness that Microsoft's design departments have had in putting choreographies on the front stage. Furthermore, analysis of choreographies reveals a clear framework of design principles that repeat in different scenarios. Assessment of these principles helps to explain how the interaction choreographies affect the user's interaction choreographies, and also, prudent generalizations on what kind of influences do these choreographic principles have on the user's kinesthetic experience can be made.

5.2 Form factors

Technological designs in Productivity future vision are generally speaking based on five distinct form factors; mobile resources, table-top screens, smart walls, wearable technologies and small-sized smart objects. All of these objects or intelligent interactive elements have effects on the users' movement, position in space, posture and sensuous focus. These general principles help to understand how the technological designs influence the on-going interaction choreography from the perspective of the embodied user.

First category of smart objects consists of mobile devices that can be hand-held devices in size of a business card, a smartphone, a tablet computer or a newspaper sheet. Individually these devices possess basic functionalities such as they provide access to the Internet and they are operated mostly through direct touch on the screen. Smallest of the devices are easy to carry with so that they can be utilized flexibly in mobile communication, and additionally, in actuation as well as addressing and commanding external interfaces. Operation of these devices in the basic position concentrates the user's visual and tactile focus on the screen. Kinesthetically I felt the usage of small handheld devices pleasant while performing short movement continuums but restrictive in prolonged use. Larger screens, instead, enabled utilization of broader movement trajectories. Personally I consider the possibility to use broader movement dimension as to convey better user experiences since larger areas on the body become involved. This is naturally also a question of personal preferences. However, the smartphone and tablet-size interfaces performed better in situations where the actual data manipulation was mediated by the hand-held device but visually presented on an external display, such as a smart wall or a larger desktop screens and wall-mounted displays or on top of a table surface display [see ex. 1; 2; 5; 6]. Therefore my general conclusion regarding to smart handheld devices based on analysis of Productivity future visions (2009; 2011) is that their individual utilization is rather clumsy but they perform quite well in operating "an ecology of resources" such as sharing screens and manipulating data on a host device's screen.

Second group of smart objects introduce large horizontal touch screen surfaces to be utilized as interfaces for information sharing and processing. When operated individually these smart surfaces serve as ordinary tables. The general advantage of horizontal interfaces is that when other smart device is positioned on top of them the smart surface can immediately visualize information carried by the object [see ex. 7] or share and scale this information [see ex. 2]. Information resources could also be sent directly from a table-top-interface to other device with a small smart object, such as smart pen, to a smart wall [see ex. 4] or information can be manipulated with a smart object [see figure 10]. Smart tables increase the usability of visual information within the user's arm's reach. Ability to manipulate information through hands while sitting on a chair or standing by a desk makes the table-top-surface as a flexible interface that enables versatile choreographic designs. Moving the content through hands in the immediate visual field would enable combinations of augmented feedback, for instance vibrotactile and auditory. This form factor has much potential to be developed further.

Third group is smart walls or windows that can be used as displays [see sc. 4; ex. 4, 9, 11, 12, 15, 17, 18] or decoration [see sc. 3 in Productivity future vision, 2009]. Individually the smart wall can present static images yet the true value of this interface lies in interactive applications. Wall provides a wide canvas for projecting information in a team meeting [see sc. 4] or enables play with movement through real-time motion graphics [see sc. 8] that can significantly alter the original context. Smart wall is a solid element that can be manipulated beside of it through touch or from a distance with a smart object. Closeness to the wide and often relatively high interactive element enables usage of limbs at the total arm length and moving along the interface. These kinds of movements are needed in the offices not only because of useful applications in terms of task realization but also to support healthy choreographies where the user's whole body can be active. Smart walls are promising in bringing necessary fluctuation between tasks necessitating close sensuous focus and precise micro movements, such as operating a smartphone, and larger movements that stimulate the rough motor processing, such as organizing post-it's on a large surface through ample movements.

Fourth group is wearable technology such as smart glasses or watches. These gadgets enable more flexibility for the people-centric sensing since the information about the user's position and, for example, arm's movement can be used in creation of contextual applications. This category of smart objects enabled free exploration of intelligent environment. The user basically carried the central resources for augmenting the intelligent environment around her. Wearable technology and such applications as see-through augmented reality sets the user free from fixed interactive elements, for instance smart table-top screens or smart walls. Nevertheless, the wearable technology examples did not address the tasks of information sending or re-modelling of data visualizations and therefore deeper analysis concerning these choreographies was left out of the analysis.

Fifth group is small smart objects that are just normal everyday objects that have been added possibilities to possess information and possibly to use their own sensors and processing to analyse and visualize basic information on their functioning [see coffee mug in sc. 5; Productivity future vision, 2009]. Whereas systemic applications of intelligent environments will leave us to wait for their introduction for a while, these kinds of small applications will most likely become increasingly popular in the near future.

5.3 User-driven choreographies and networked resources

The fundamental factor characterizing human-computer interaction choreography in Productivity future vision is that the devices are used as networks of interconnected resources. Furthermore, the user is actively involved in defining the network of devices that are used in the on-going interaction through addressing the devices through subtle micro-movement commands. Addressing of a particular device can be accomplished, for instance, through pointing a device with other device under the user's control or positioning the devices in relation to each other [see examples 1, 2] or using the body in commanding the devices [see example 3]. Based on the choreographic analysis of Productivity future vision I argue that when the devices are able to interconnect seamlessly and new digital resources, such as large embedded interfaces on smart table surfaces, smart windows and smart walls become popular, it will be no longer meaningful to stick with the limited choreographic possibilities offered by a single device. These ideas lead to a new kind of understanding on interaction design where user interfaces are treated as networks of digital resources that are characterized by adaptive functionalities. This way of handling human-computer interaction necessitates an understanding of the user that emphasizes the user's agency. Active user harnesses appropriate resources in her use that are available in the particular interaction setting. Thus the user becomes actively involved in the ways interaction choreography unfolds in specific contexts. Implementation of these ideas leads to a transformation of the interaction design discipline as well as the entire industry.

Flexible interactions and spontaneous internetworking of smart technical displays is strongly supported by the definitions of choreographic design. When choreography is seen to include both the plan for the action, the action itself and all the agents it draws together (Parviainen, Tuuri and Pirhonen, 2013, p.109) the choreography suggest engagement of the user with the broader context of interaction. Several examples showed that knowledgeable user links different resources in order to facilitate purposeful interaction [see examples 1, 2, 9, 10, 13, 20]. These examples where initially designed to demonstrate that choreographic design can have a positive effect on the work productivity and, based on my understanding, I agree that it really seems to be so.

5.4 Users freedom in choreographic performance

Interesting factor in the data was that there were differences on micro movement continuums and interaction strategies that, in principle, aimed at accomplishing an identical task, for instance, sending and sharing information [see ex. 1, 2, 4]. These tasks were typically short movement sequences that entailed one to four movements. Differences in the utilized interaction strategies were partly caused by the assortment of devices involved in the interaction and natural choreographic strategies related to these devices, [see ex. 2 on using a tablet computer on top of a table surface interface]. However, also example-pairs where the assortment of devices and the purpose of interaction are nearly identical can be found [see examples 1 and 4]. These examples presented a use situation where information was shared over a distance from a hand held device to an external vertical interface. Additionally, in both of the examples the data was then re-modelled on the receiving display through usage of the sending tablet computer device. In example 1, information was sent from a tablet computer to a desktop computer screen by dragging and dropping the information whereas, in example 4, the data was sent from a tablet computer to a vertical wall surface interface by a tapping movement. These interaction settings are so similar that interaction choreographies could be utilized interchangeably. The finding shows that different choreographic strategies can be interchanged between use contexts if the devices' form factors and positions in space and alignment in relation to each other form a similar kind of composition.

The user's ability to interchange choreographies based on her understanding on the functionalities and principles on the devices' interaction is a very interesting finding from the perspective of choreographic analysis. The overall variation of choreographies clearly indicates that in the case of Productivity future vision, micro movements are becoming contextual regarding to the most routine tasks. In addition, the above example shows that the user has the freedom to choose among several optional choreographic strategies. Based on this finding, the user can be seen as an active agent that performs her choreography based on personal skills, technological knowledge and interactional preferences. This reminds about the idea of the user as a hybrid, whose choreographies are defined by her ability to utilize 'things' as constitutive elements of her choreographies. On the other words, the use of personal mobile devices, smart objects and embedded interactive elements widens the user's reach and capabilities within the intelligent ICT environment. The user's capability to act as an agent "inside" the computer system and on the interface becomes central to the user's competence in utilizing intelligent ICT environments. The user inhabits these environments and is affected by them and becomes dependent on the possibilities provided by the environments. (compare Thrift, 2008, 10; Kaasinen, et. al., 2013). The development of intelligent environments is characterised by mutual learning of the individual user and, most likely, the computer system that learns about the user's personal preferences and ways of interacting with and through the physical spaces, ecologies of resources and contextual applications. Together these elements consist the intelligent environments and, eventually, the smart city.

It is an encouraging vision that, already in the near future, meaningful interactions can happen progressively more detached from single-personal-device, away from kinesthetically stiffening desktop workstations. The choreographic design and innovation will have a huge impact on how our everyday life happens. Design for user-driven choreographies in an adaptive intelligent environment has a great potential to facilitate utilization of the creative potential of the body in constructing knowledge, support embodied problem solving and deepening social collaboration, which I believe to have a significant positive impact on the work productivity and quality of life.

5.5 Continuums of visual-haptic focuses

Dance practice led me to think about the interrelation between the visual and tactile-haptic perceptual systems and their role to the user's performance. Especially the analysis of spatio-temporal progression of visual focuses in space in on-going interaction seemed to affect the user's body during the interaction. The user operates technology mostly through touching the screens, through moving the objects and by positioning the objects in specific relations to each other. Especially during the use of a touch screen interface, precise operation of the devices necessitates the user to direct her attention frequently towards tactile operating surfaces. In return of the user's tactile commands and movements the computer provides visual feedback to the user. The emerging visual content also captures the user's attention. Tactile-visual input-output-loop between the user and computer system can be considered as basic organizing principle of the human-computer interaction in the Productivity future vision.

Tactile-visual loop influences the choreography both functionally and experientially. I have analysed all ten scenarios based on the relationship between these two sensuous focuses and labelled the differences in three categories as superimposed, proximate and mediated coupling. The tables can be found in the appendix (see ANALYSIS TABLES). These invisible aspects of interaction choreography turned to play a significant role in the user's body alignment, extensiveness of movement trajectories and muscle tension. Moreover, this approach might be applicable in conducting choreographic analysis concerning intelligent ICT environment.

The tactile operating interface and visual receiving interface can be the same, i.e. a smartphone screen. This kind of interface creates a superimposed tactile-visual sensuous coupling. This means that the user perceives simultaneously both the tactile intrinsic and visual extrinsic feedback from a small surface area. Superimposed focus on a very small area turns the user's body towards the focal point of the interaction. In superimposed coupling movement range is restricted, especially when using small screens. Wider screens, such as table top screens enable more natural movement trajectories and, for instance in visualization modelling, enable grasping, scaling and turning the visualization with two hands. However, based on my experiences on dancing the choreographies I would recommend avoiding lengthy movement sequences with superimposed visual-tactile coupling since it has tendency to isolate body movement, stabilize the body and cause muscular tension. The circular visually augmented mouse interface in scenario 3 [ex. 14] can be used as a type example of failed adoption of superimposed coupling because the choreography creates a rigid position with extended arm, and this position is extended over a lengthy micro-movement sequence.

Visual-tactile coupling can also be proximate that refers to situation where the user operates a logical and simple tangible user interface, such as a computer mouse, that does not require constant visual follow up to perform the critical tasks. Instead the user's proprioceptive feedback can be strengthened by projecting visual feedback on the screen, such as the mouse and arrow where the movement of visual arrow corresponds to the user's internal experience of the movement of her hand. This kind of interaction supports more open body alignment compared to superimposed coupling. In the scenario 3 the fetching of data from desktop computer to a tablet computer serves as an example of implementing choreography based on proximate visual-tactile coupling [see ex. 3].

Third possibility to define visual-tactile coupling as mediated which means that tactile operation of an operating device controls visual display over a short distance. This is the case when the user adopts visual displays that are situated on the wall and uses those resources to gain better or bigger visual display for her interaction. Scenario 5 [ex. 5] provides an example of a sequence where several devices are used as visual interfaces whereas data control is mediated through handheld device. Mediated interactions could be adopted especially in cases of data fetching from a device to another over a distance.

The result of this part of the analysis shows that dynamic relations between visual and tactile focuses have a comprehensive influence on the user's body during the interaction. Furthermore, when sight travels on distributed screens provided by a device network it has the potential to enable choreographies that activate the user's body. Therefore I recommend intelligent environment applications that build on the possibilities of a device network. This kind of an interaction setting can support choreographies that generate refreshing changes in body alignment and posture, as in the examples of intelligent office [sc. 4] and intelligent home [sc. 5].

5.6 Dancing as a choreographic practice

In this research the choreographic analysis was applied through phenomenology, hermeneutics of the body and in reference to the tradition of kinesthetic dance research. These elements were adopted because of the need to understand bodily felt nuances of the studied interactions. I consider dancing as central activity for the study of movement choreographies. Dancing was a choreographic practice that had several benefits. Dancing facilitated creation of an embodied understanding on the technological context and the ideas of choreographic principles related to typical interactions with certain kinds of technological forms. In the end, dancing was the only possible way to assess the kinesthetic experience associated with micro and local level choreographies as inner experience of the body.

Integration of dancing into this study required arduous work. Intelligently dancing became justified through phenomenological methodology but applying dancing in the research practice required investment in studying kinesthetic research tradition. Naturally the actual design research through dancing needed a fair time investment as well. The process of embodying choreographic principles as the body's knowledge needs time and effort as does any other process of learning a new skill. Building on the ideas of Deidre Sklar, I see choreographic practice as a parallel process of body-making and meaning-making (compare Sklar, 2000, p.74). Principles of choreographic analysis, the technological context and Productivity future vision were all integrated through dancing. Additionally, dancing was a source of ideas and insight that enabled me to solve problems that emerged during the research process.

I consider the choreographic practice as a relevant method for conducting analysis on interaction design in movement oriented spaces and contextual services that are based on people-centric sensing (see Gubbi, et. al., 2013, p.1657; Parviainen, Tuuri and Pirhonen, 2013). Recent technological breakthroughs allow the design to start from the movement. I see it perfectly reasonable to start sketching contextual movement-oriented services from the standing point of the body-in-movement. Dancing is a useful tool for assessing spatial dimensions of physical structures, movement affordances as well as assessing sensuous dimensions of experiencing the space as visual-tactile continuums. Understanding on these premises becomes useful when thinking about adequate positions for visual interfaces that enable useful internetworking of digital resources in the space.

Many choreographic principles have become integrated into my body movement vocabulary and understanding thanks to extended dancing period of the industrial choreography – interaction choreographies became knowledge of my body. Therefore my body can be considered as a sophisticated instrument that can be creatively used in assessing and even designing movement-oriented choreographies that are based on choreographic principles similar to those utilized in crafting Productivity future visions. Dancing can be considered as thinking-in-movement (see Sheets-Johnstone, 1999), and it can be juxtaposed with other established ways of prototyping in the design process. When dancing is cleverly used in the design process it can significantly facilitate the process of designing place-specific intelligent solutions and, therefore, I recommend application of 'dance as choreographic practice' not only in the analysis of intelligent ICT environment, as in this study, but also in designing future intelligent ICT environments.

5.7 Interaction choreography in intelligent ICT environments abstracted

By the end of this study, my understanding on human-computer interaction choreographies in intelligent ICT environments is that interaction choreography unfolds as a systemic and parallel sensory / sensuous procedure between the embodied user and the computer system, and that only a fraction of generated data is used for applications on the interfacing layer, which is the physical intelligent environment. As the body exercises its knowledge through movement and the computer systems' central role is to extend the reach and capabilities of the body, interaction design should be considered to have an embodied basis. When intelligent ICT environment design is based on this understanding and designed as a system, the interaction design seeks solutions that build on the strengths related both to embodied capabilities of the human user and computational and memory resources characterizing the computer system and information infrastructures. Together these resources that are fundamentally different in nature can result as an outstanding choreographic performance in dedicated contexts of use.

The choreography is characterised by parallel processing of information. When it comes to the user, most of the processed information is tacit yet the user's unconscious perception on her body is extremely important, because her knowledge-in-the-body and her environment influences on the user action. When the computer system is considered, the information can be stored and analysed in great detail but only tiny part of the information will be processed in real time. Even smaller portion of it will result as visible and applicable feedback for the user. However, this contextual information that is processed in real time and on-demand holds the central promise and brings advantages characterizing the next generation ubiquitous computing web. Therefore it can be stated that human-computer interaction within an intelligent ICT environment is a complex and parallel information processing procedure where only a fraction of the sensuous or sensory data extracted from the environment will be used in the end-user application.

There is a thin interfacing layer that enables meaningful integration of the knowledge of the body and the information possessed by the computer system. This thin layer is the common ground that creates the "living space" for human-computer interaction in intelligent ICT environments. For creating great interaction choreographies that result as great experiences, the effort to understand the transforming interface and also "hidden" layers of information on both human and computer sides needs to be considered for the choreographic innovation to happen.

_CONCLUSIONS

This study described choreographic and kinesthetic approach to intelligent environment design through a case study research. Choreographic approach is a method that was in this study applied for studying what kind of influences technological designs do have on the user's movement and experience on individual and inter-subjective levels. Movement analysis was realized through dancing sequences extracted from the movement material presented in Productivity future vision produced by Microsoft. Choreographing was used as a technique to frame and compress kinesthetic material, which basically meant re-composing scattered movement sequences from the original vision into a seamless and logically progressing movement continuum. Dancing was also a method for turning the 'moving images' into a personal lived real-life experiences that enabled the analysis of the felt qualities of the movement. The resulting choreography was documented in a video format. It created stand-alone statement of the influence of corporate choreography on the technology users' bodies and movement; 'pure movement' was dismantled from visual and technological distraction which enabled me to highlight the choreographic influence on the user's body (compare Industrial choreography to Productivity future vision 2009; 2011). Simultaneously dancing was an approach for generating insight into data as well as presenting an analysis of it – embodied knowledge might not be fully verbalized but it can be performed. The scientific validity of the research method was argued leaning on phenomenological methodology.

Research data – the Productivity future vision – handled future technologies in intelligent workplace, school, transportation environment and home environment from user-centred perspective. These vision concentrates on describing information and communication technologies and, consequently, data sending and fetching and real-time data modelling and visualizations were selected as special focus in the study. Data provided a rich set of scenarios where movement choreographies had been given a central stage. Therefore these scenarios set good premises for choreographic analysis. The research investigated what kind of influences does the choreographic designs presented in the research data have on the user's kinesthetic experience. Another studied topic was to examine what kinds of understandings can be created through embodied orientation to research of human-computer interaction choreographies.

General finding is that the research data is designed with high priority to choreographic design. The visions aim at conveying impression of unity between the user and the intelligent environment and enjoyment of interaction. Choreographic practice helped to see behind the appearances of human-computer interaction presented in the vision. Dancing revealed examples on good choreographic designs and also choreographic mistakes such as difficult movement sequences and stiffening micro movement continuums that may cause muscular tenseness. Choreographic approach covers different levels of the choreography and the research data was evaluated based on micro and local level choreographies.

Micro level choreographies followed more or less strictly predefined movement sequences that dictated the user's physical presence starting from posture, position in space, introduced continuum of micro-movements in the overall movement sequence and the relationship between the user's movement and the intended human-computer interaction. Positive feedback was given to scenarios characterized by intuitive movement sequence and logical visual-haptic couplings of augmented and internal feedback. Essential factor in a good choreography was that it enabled coherent kinesthetic continuums. Especially interactions on large table-top interfaces and smart wall surface enabled usage of broad movement repertoire, rotations of the torso and upright position. Also the combinations of handheld devices and embedded interactive elements such as large screens or smart walls received generally positive feedback from their ability to free the user from her workstation. The most transformative choreographic innovation, however, is the flexible usage of the technological resources and possibility to dynamically organize the interaction in the intelligent environment through networking abilities and flexible usage of all available visual displays.

In contrast, the criticism towards micro level choreography was targeted towards such choreographies that led to stiffening of the user's body without any apparent reason. Such choreographies did, for example, require the user to operate on an interface that was restricted to marginal surface area with extended arm. This resulted as solid posture and isolation of movement in the upper body. When prolonged in duration, this kind of solid position can lead to health problems. I also criticized some individual movements because they were hard to realize and some were even painful. These kinds of examples proved the usefulness of embodied choreographic analysis in localizing successful choreographies and eliminating failed choreographic designs from the vast movement material.

On the local level choreographies positive result was that most of the smart objects can be used flexibly in different combinations that facilitated organization of the interaction within a social situation. The users could use their own devices, they could adopt a third-party device for interaction and they were also able to integrate data between their own device and an external interface. The local ecologies of resources could be flexibly integrated into individual as well as to interpersonal interaction choreographies. In a couple of discussed cases the surrounding space was also favourable for creation of shared project ownership and efficient group dynamics in participatory data processing. This requires a design where choreographic design is optimized for the group size and typical tasks. These local level choreographies promoted the idea of environmental structures as moving-oriented spaces. In these examples the micro choreographic continuum was integrated in a meaningful way into the local social needs of the users.

The typical reasons for criticizing presented local level choreographies were mostly related to too complex interactions with too little augmented feedback from the computer systems' side. There was simply too little information to facilitate the users' movement and thus the system's requirements for the user deserved criticism of being misleading or vague. Such choreographies were mostly based on high expectations on the capacity of individuals to apply developed embodied skills within a complex task between several individuals. This led to unrealistic scenarios from the perspective of local level choreography although many of the micro choreographies were well designed.

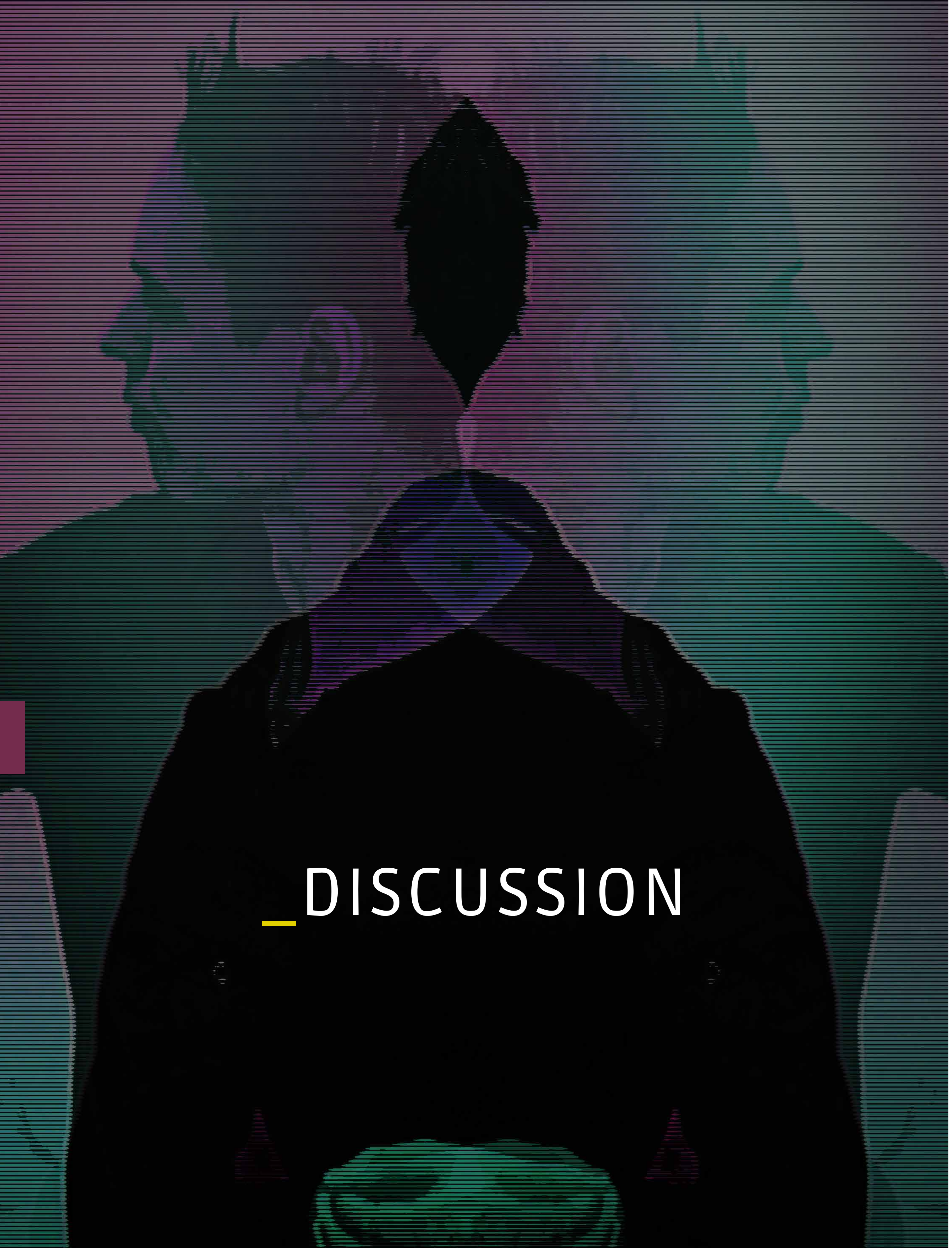
In general I found adoption of the multi-level analysis characteristic to choreographic analysis introduced by Parviainen, Tuuri and Pirhonen, (2013) justified. Simultaneous analysis on several scales provided a better picture of the feasibility of the choreographic design than analysis based on only one individual scale would have been able to provide.

Choreographic designs influenced most to the user's position in space, ways of handling the devices and micro-movement sequences associated with realizing a certain task. Choreographies affected most on the user's kinesthetic experience through movement sequences deriving from form factors and related interaction patterns typical to specific visual and tangible interfaces. Also the structuring of space influenced choreography. Third factor that influenced movement experience was related to combinations of interfaces in a movement sequence. In general, designed interaction settings influenced the users' movement, position in space, posture and sensuous focus during the interaction. It is noticeable that also the user's knowledge and skill of using the technology had an effect on the resulting choreography and, naturally also to the felt sensation of the choreography.

In this research dancing as a choreographic practice did enhance the understanding on the felt experience of the choreographies and enable me to internalize an idea about the broader technological context of intelligent environment. Ideas on embedded sensors and ubiquitous computing web was difficult to grasp and dancing significantly facilitated understanding the influence on these major developments to the end-user applications. Dancing together with the concept of choreography also highlighted the user-centred mind-set. Dancing choreographies combined the movement and the physical / social context of interaction and thus facilitated positioning the technologies in assistive role that was intended to support the user's activities. In so doing, dancing supported coherent framing of the design space and emphasized the influence that design choices will have on the users' everyday life. The most significant finding that emerged from dancing was that the continuum, trajectories and relationships of visual-tactile focus has a significant influence on the body posture, alignment, and reach of movement trajectories. There are usually many visual displays in the intelligent environment and device's ability to form ad hoc networks

creates abundant possibilities of combining and re-combining interactions based on technological combinations. Utilization of these distributed resources affects the user comprehensively. Due to the late emergence of this finding, it could not be addressed but superficially. Analysis of the role of visual-tactile coupling and how spatial shifts in visual focus influence the micro choreography of an individual user remains to be studied in further research.

To conclude, developments towards fully functional intelligent ICT environments will shift how we use our environments. The data used in this study suggests that the future interactions will be decoupling from single-device interaction logic that is still prevalent today. The internetworking of the devices will introduce completely new kinds of services where personal devices serve mainly as extensions of the users' bodies and enable access to third-party resources. Full integration of ecologies of resources will enable the users to interact with friends, relatives and colleagues more flexibly than ever before. New contextual service experiences will be introduced in urban spaces, transportation services, educational facilities and homes. This will set increasing requirements on development of methods for designing more accurate, timely and needs-based contextual services. Choreographic approach is one method that has potential to mature as useful tool for interaction designers for designing for intelligent ICT environments, yet, as a newly introduced method, much work for developing the method remains to be done.



_DISCUSSION

Whereas dancing provides a powerful tool for designers to organize human-computer interactions in space, time and movement, in my opinion, the verbalizations on the experiences of interaction remained clumsy for the design use. Verbal descriptions of choreographies may not be optimal in conveying the felt sensation of movement and it hardly makes a convincing argument of selecting certain designs on top of the others. Translating danced knowledge-in-the-body into language can be considered as one possible way for explicating an idea of an intended experience. Initial verbalizations of kinesthetic experience of body-in-movement set the stage for discussion about pretty slippery notion of movement experience. On the other words, when it comes to description of movement experience what might be more interesting than verbal descriptions might be the reactions and ideas, and hopefully also inspiration that results from these descriptions. Additionally, instead of writing experience descriptions to the designers who might not be willing to even read through them, it might be much more interesting to involve designers to sensitize their bodies to nuances of movement and combine this inherent awareness with their understanding on real-life applications.

> *"Design has long shaped the possibilities of how we can use our bodies – now it's time for their movements to shape how we design"*
>
> / Olli Poutanen

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APPENDIX I: ANALYSIS TABLES

() = **important visual-tactile transition**

/ = **change in person conducting the interaction**

– = **distinction between different interactions**

[] = **two or more devices are addressed by the user through the same command**

Scenario 1 from Productivity future vision (2011)

Qin at Jeff's office: engineering meeting Timeframe in the vision: 0:03: 31 – 00:04: 22

Sc. 1 / Ex. [1–2]	Users	Devices	Micro-movements	Type of Devices
	2	3	11	(1) Tablet device (2) Desktop computer (3) Pen-object

Continuum of visual focuses [(1) – 2] – 1 – 1 / 2 – 2 – 2 – 3 – 2 / 1 / 2

Scenario 2 from Productivity future vision (2011)

Telepresence between Ayla and her daughter Melanie Timeframe in the vision: 00:04: 22 – 00:05: 53

Sc. 2 / Ex. 1	Users	Devices	Micro-movements	Type of Devices
	2	5	10	(1) Tablet device (2) Pen-object (3) Smartphone (4) Wall-mounted display (5) Tabletop display (surface)

Continuum of visual focuses 1 – 2 – 1 / 3 – (4) – 4 / 1 / 4 / (1) – 5

Scenario 3 from Productivity future vision (2009)

Qin at his private office Timeframe in the vision: 0:01: 16 – 0:02: 07

Sc. 3 / Ex. [1–2]	Users	Devices	Micro-movements	Type of Devices
	1	2	10	(1) Smart window (2) Desktop computer screen 1 (3) Desktop computer screen 2 (4) Desktop computer screen 3 (5) Tablet computer

Continuum of visual focuses 1 – 1 – 2 – 3 – 4 – 3 – 4 – 4 – 3 – 4 – [3 – 5]

Scenario 4 from Productivity future vision (2009)

Team meeting at the office Timeframe in the vision: 0:02: 53 – 0:03: 37

Sc. 4 / Ex. [1–5]	Users	Devices	Micro-movements	Type of devices
	3	4	8	(1) Wall display (2) Tabletop display (surface) (3) Tablet computer (4) Pen-object

Continuum of visual focuses 1 / [2 – 4] – [2 – 4] / 1 – 3 – 3 – 3 / 2

Scenario 5 from Productivity future vision (2009)

Senior advisor's smart home Timeframe in the vision: 0:04: 10 – 0:05: 10

Sc. 5 / Ex. 1	Users	Devices	Micro-movements	Type of devices
	1	3	13	(1) Mug-object (2) Foldable screen (newspaper size) (3) Wall-mounted display (4) Handheld controller

Continuum of visual focuses 1 – 2 – 2 – 2 – 2 – 2 – [3 – 4] – [3 – 4] – 4 – [3 – 4] – [4 – 2] – 2 – 2

Scenario 6 from Productivity future vision (2009)

Airport orienteering Timeframe in the vision: 0:02: 07 – 0:02: 56

Sc. 6 / Ex. 1	Users	Devices	Micro-movements	Type of devices
	1	2	12	(1) Smart glasses (2) Split-screen smartphone (3) Smart watch

Continuum of visual focuses [3 – (1)] – 2 – (2) – 2 – 2 – 2 – 2 – 2 – 2 – 2 – 2 – (2)

Scenario 7 from Productivity future vision (2009)

Meeting at the airport business lounge Timeframe in the vision: 0:03: 37 – 0:04: 10

Sc. 7 / Ex. [1–2]	Users	Devices	Micro-movements	Type of devices
	2	3	6	(1) Tabletop display (surface) (2) Memory-device (key fob) (3) Memory-device (card-object)

Continuum of visual focuses [3 – 1] – [2 – 1] – 2 – (1) – 1 – 1

Scenario 8 from Productivity future vision (2009)

Kids and telepresence blackboard Timeframe in the vision: 0:00: 00 – 0:00: 34

Sc. 8 / Ex. [1–2]	Users	Devices	Micro-movements	Type of devices
	4	1		(1) Vertical touchscreen

Continuum of visual focuses 1 – 1 – 1 – (1) – 1 – 1

Scenario 9 from Productivity future vision (2011)

Qin and interactive marketing at the subway station Timeframe in the vision: 0:01: 19 – 0:02: 07

Sc. 9 / Ex. [1–2]	Users	Devices	Micro-movements	Type of devices
	1	2	8	(1) Smartphone (2) Smart marketing display

Continuum of visual focuses 1 – 1 – 1 – 1 – 1 – [(1) – 2] – 1 – 1

Scenario 10 from Productivity future vision (2011)

Ayla and Jeff model statistics in telepresence Timeframe in the vision: 0:02: 28 – 0:03: 32

Sc. 10 / Ex. 1	Users	Devices	Micro-movements	Type of devices
	2	3		(1) Desktop computer (2) Tabletop display (surface) (3) Pen-object

Continuum of visual focuses 1 – 1 – 1 – 2 – 1 – 1 – 1 – 1 – [2 – 3]