Working out Work

From Personal Informatics to Redesigning Work

Fatemeh Moradi

To my loved ones

Akram, Alireza

&

Ershad

بیا تا گل بر افشانیم و می در ساغر اندازیم

فلک را سقف بشکافیم و طرحی نو در اندازیم

(حافظ شیرازی)

Rose petals let us scatter & fill the cup with red wine

The firmaments let us shatter & come with a new design

(Hafez Shirazi)

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Abstract

"Personal Informatics" (PI) and "Quantified Self" (QS) are two contemporary notions in the field of Human–Computer Interaction. Such hardware and software systems gather personalized quantified data and visualize them for the purpose of supporting self-reflection. Many of these systems focus on breaking the habit of prolonged sitting and increasing physical activity in our daily lives. The problems associated with the sedentary lifestyle and prolonged hours of sitting have been noted in many studies. In fact, stationary behavior is a risk factor for cardiovascular disease, diabetes and certain types of type of cancer. Nowadays we, as adults, spend more than 8 hours a day on work and work-related activities. As a consequence, the time spent sitting in office workspaces contributes to the majority of stationary behavior in our daily lives. Throughout history, designers and technocrats have constantly redesigned workspaces in attempts to increase work productivity and efficiency. Thus "modern" office work configuration includes desks and stationary computers and so office workers have become accustomed to prolonged sitting in their workplaces.

In relation to this research problem, I have worked on my PhD thesis within the context of a four-year cross disciplinary research project in which we have been exploring ways of increasing physical activity and breaking the habit of prolonged sitting among office workers. This is a thesis in informatics and closely allied to medicine and it focuses on studying how contemporary office work affects the body and how to redesign this context. For this thesis, I conducted three empirical studies and designed and developed two prototypes - the "*NEAT Lamp*" and the "*Talking Tree*". The "*Sport Co.*" study was the first quantitative study, and was followed by two qualitative observational ethnographic studies – the "*Housing Co.*" study and the "*Health Co.*" study. The research process adopted during the work can be described as an intertwined process consisting of three methodological approaches: observational ethnographic studies, concept development and prototyping. These three came together to form a coherent contextual design process for tackling the research question, "*How can we approach the design of work in today's offices in order to make office workers more physically active in their workspaces?*" This process resulted in five papers presenting various aspects and results of the research conducted. The results cover the role of bodies at work by considering the history of work design, knowledge about the local movement and mobility patterns of office workers in

modern office spaces and eventually the design and evaluation of the two prototypes introduced in this thesis. Finally, I conclude this thesis by highlighting my overall contributions. The first contribution targets designers willing to design for increasing physical activity and breaking the habit of prolonged sitting in workspaces. In relation to this I introduce a design space as a tool for understanding the design of work in relation to worker's bodies. The second contribution highlights how observational ethnographic studies, concept development, and prototyping can be combined when exploring the context of physical activity in office environments and it shows how contextual design might be a suitable approach for such studies. In addition, it emphasizes ways for how we can redesign work and expand our contextual knowledge. This, by examining and evaluating interactive prototypes in real office settings.

Preface

Finally the day has come when I am writing the final words of this thesis. How fast the time has passed from the days that I was a little girl dreaming of becoming a writer while playing in the living room and staring at all the books on the bookshelf. Today I am making the final changes to my thesis, a piece of work that summarizes the research I have done over the past four years: four precious years that have shaped who I am today and how I see the world. Despite all the challenges and obstacles along the way, today I am able to finish this PhD research. Although I didn't become the writer that I expected, I ended up in a profession that very much deals not only with writing, but also with being creative, thinking about abstract theories and analyzing and making solid arguments. Thus, this desire to become a writer sometimes directed me towards taking an abstract and philosophical approach while describing the process of my research. And so I was always challenging myself to keep the text grounded within the research process that I conducted. The outcome of all these challenges is "*Working out Work*".

The title "*Working out Work*" highlights the essence of this thesis. According to The Concise Oxford English Dictionary, the phrase "*work out*" has three meanings: a) "be capable of being solved", b) "develop in a good or specified way" and c) "engage in vigorous activity". "*Working out Work*", touches upon on all three of these meanings. From one perspective, it deals with understanding or figuring out the work that has resulted from decades of constant designing and redesigning. From another perspective, this thesis describes an investigation of how to increase physical activity in workplaces among office workers and so it examines ways of working out at work. I hope that this thesis will be of interest to all those researchers, designers and technocrats who investigate ways of increasing physical activity in workplaces. If you are an office worker spending the majority of your days seated or you are just interested in the history of work, then you might also find this thesis a fascinating read. Although office work is associated with prolonged sitting I had the advantage of access to a treadmill during the time that I was writing parts of this thesis. During the several months that I had this opportunity, I walked approximately the distance from Amsterdam to Brussels.

Acknowledgements

Looking back on the process of writing this PhD thesis, I come to realize that it has been a life-changing experience. As a journey, it is hard to compare it with any other experience I have had. One of the most fascinating parts of this experience is that it was a collaborative effort that helped me to learn, understand and discuss theories, methods and ideas. Thus there are many people that I would like to thank. First and foremost, I would like to thank my supervisor, Mikael Wiberg. Mikael, you have been a mentor and support throughout the process of conducting the research and writing this thesis. So many times you helped me to rethink and restructure my vague ideas, provided me with guidance on how to present my arguments and how to put my thoughts into words. At times when I faced a challenge or became frustrated during these four years, you always helped me to gain back my strength and get back to work. I cannot thank you enough for all the things that I have learned from you during this collaboration. No matter what the future holds for me I will always remember you as my "*handledare*". I would like to thank my second supervisor Andreas Lund, for stepping up to this role at a time when I was lost in my massive amount of data. Andreas, there is a humble quality in your character that makes you a perfect supervisor and I found myself lucky to know you and work with you. Your thoughtful comments and questions during the final seminar helped me to develop this thesis further and I am grateful for our discussions which shaped the contents of this thesis.

This PhD thesis would have not have been possible without the efforts of all the members of the "*InPhAct*" project, especially Tommy Olsson who acted as my third supervisor. Tommy, you believed in me at times when I doubted myself and this means the world to me. Thank you for all your precious comments and feedback about my research process and my papers. In addition, I would like to thank Viktoria Wahlström for helping me to conduct my studies and being a key player in coauthoring our paper. Parag Deshpande, the designs you created during the "*InPhAct*" project have inspired me and played a massive role in finishing this thesis work, so thank you. And finally Frida Bergman, it has been a great privilege to share this journey with you.

My deepest and sincere gratitude to all of the hard-working office workers that I observed for months. I do apologize if I made you uncomfortable in any way. Without you there is no meaning to this thesis.

And then… my family and friends all around the globe. It is so hard to thank my parents in words for all the sacrifices they have made for me. Mom, Dad, thank you for all the support you have given me. I am truly blessed to have you by my side. To my amazing brothers Hamed and Hamid, you two are the best. Thank you for all the stories and memories. Those were the days. Zahedeh Bashardanesh, you are one of a kind. And to all of my friends who have always had my back.

 Last but not least, to Ershad. Thank you for giving me the courage to dream and helping me in pursuing these dreams. Your love has taught me patience and gives me motivation to push barriers to achieve the seemingly impossible.

Part I:

Information Technology, Bodies & Offices

Introduction

"Personal Informatics" (PI) and "Quantified Self" (QS) are two contemporary notions within the field of Human–Computer Interaction (HCI) (Li, Dey, & Forlizzi, 2010; Swan, 2012)[1]. They mostly refer to hardware and software devices that gather personal quantitative data and visualize these for the purpose of providing self-reflection (Li et al., 2010; Ploderer, Reitberger, Oinas-Kukkonen, & van Gemert-Pijnen, 2014). In recent years, there has been a rapid increase in designing and utilizing such systems (Swan, 2012, 2013). In relation to the idea of designing for bodily interaction, a growing number of PI and QS systems have been produced to break the habit of sedentary behavior and motivate individuals to increase their physical activity (Ploderer et al., 2014). In this thesis, I focus on these PI and QS digital systems.

Such body- and movement-centered systems have been developed in different forms from simple step counters to complex smart watches. A handful of such products have recently been made available commercially, including Fitbit, Nike+, Jawbone and Apple Watch (Ploderer et al., 2014). Similarly many such computing systems have been designed and evaluated with in the HCI community from smartphone applications (Consolvo, McDonald, et al., 2008) and wearable sensors (Burns, Lueg, & Berkovsky, 2012), to ambient displays (Hazlewood, Stolterman, & Connelly, 2011; Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006). These systems support the creation of awareness of users' activity levels, helping them to increase daily movement and break their sedentary habits. Mostly these devices have been designed, constructed and used by focusing on providing lots of detailed information to the user from an individual perspective. However, recently many PI and QS designs have benefited from the use of social media in encouraging users to break their habits (Foster, Linehan, Kirman, Lawson, & James, 2010; Kamal, Fels, & Ho, 2010). A more in-depth review of these systems is provided in the related research section

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[1] In recent years these information-based feedback systems have been employed in various domains from organizing financial records, to tracking the number of books you read, from keeping track of your calorie intake to counting the number of steps you take and your physical activities (http://quantifiedself.com/guide/).

in the second part of this thesis. The growth in design and use of such PI systems has been possible because of the availability of ultra-small technology. Such designs can be viewed as a way to compensate for our current sedentary lifestyles. While the majority of designs are intended to motivate users to increase their physical activity during leisure time, there is a clear message in Public Health studies about the importance of breaking the habit of prolonged sitting during our daily lives. In other words, there is a need to design systems that encourage office workers to be less sedentary. Designing systems that motivate and encourage physical activity in workplaces is considered applicable to many fields of study, including Public Health, Architecture, Design and Informatics [see e.g. (Bergman, Boraxbekk, Wennberg, Sörlin, & Olsson, 2015; Epstein & Roemmich, 2001; Jafarinaimi, Forlizzi, Hurst, & Zimmerman, 2005;
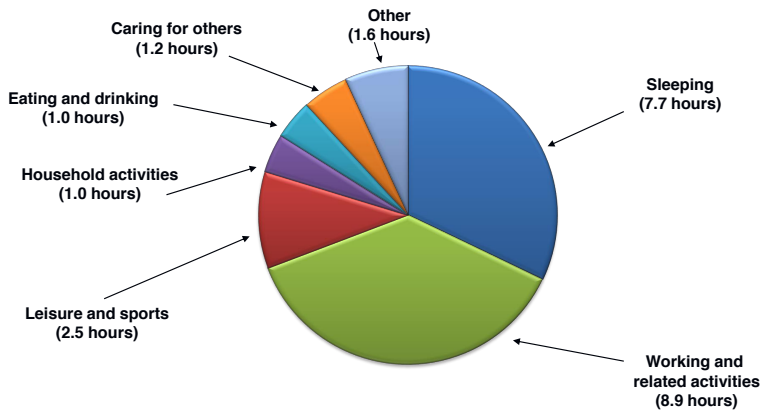
Figure 1.1. Time spent on different activities for adults aged 25 to 54 derived from Bureau of Labor Statistics, American Time Use Survey

Owen et al., 2011; Taylor et al., 2013; Zimring, Joseph, Nicoll, & Tsepas, 2005)]. As adults, we spend the largest proportion of our time in workspaces. According to the department of labor in the United States (http://www.bls.gov/tus/charts/), adults aged 25 to 54 with children spend more than 8 hours per day on work-related activities (see Figure 1.1). Thus, in order to deliver effective change in daily activity levels and break sedentary habits, achieving change in office spaces could provide considerable benefits.

This thesis is the outcome of my four-year PhD research: an attempt to investigate ways of applying the same values inherent in PI and QS designs to increasing bodily movement among workers in an office setting. HCI is a design-driven field that takes a human perspective towards IT development (Beyer & Holtzblatt, 1997). Based on the core foundations of HCI, and to gain a better understanding the circumstances of use, I investigated the context. Investigating context (Abowd et al., 1999; Benyon, Turner, & Turner, 2005; Coutaz, Crowley, Dobson, & Garlan, 2005; Dourish, 2004a; Mathiassen, 1997) and applying

contextual design thinking (Beyer & Holtzblatt, 1997; Wixon, Holtzblatt, & Knox, 1990) are common ways of approaching HCI research. One of the unique characteristics of contextual design is that steps can be skipped or prolonged based on project requirements (Beyer & Holtzblatt, 1997). In this thesis, the research process benefited from this characteristic and so I adjusted and tailored the methodological approaches used. In this thesis, the term "*tailoring*" refers to this act of adjusting methodological approaches while maintaining contextual design as the backbone and framework of the study. While conducting this research, I used three methodological approaches: ethnography, concept development and prototyping. These three approaches were modified and interwoven with one another to suit the principles of contextual design. The way this approach has been put into practice is described in detail in the third part of the thesis.

Understanding the context provided by the work setting from various perspectives, such as social or psychological, is a common practice (Kling, 1996a). In fact, offices were among the first to incorporate informatics into the domain of work (Kling, 1996b). Interventions such as administrative data processing and office automation massively impacted the design of modern work (Hirschheim, 1986a, 1986b; Zisman, 1978). However, the field of Informatics has always been both user- and context-centered and designing informatics for workspaces is no exception. In this realm, pioneers such as Rob Kling (Kling, 1996a), Lucy Suchman (Suchman, 1987) and others (Blomberg & Karasti, 2013) have conducted studies aimed at understanding the context to improve the design of information systems at work. Influenced by such key studies, others became interested in understating the role of informatics and computational systems in supporting collaboration

Figure 1.2. A working office

and cooperation at work (Baecker, 1992; Grudin, 1994).

Designing for Active Bodies in Offices

There is a need to shift our modern lifestyle away from sedentary behavior, not only in our leisure time but also throughout our workdays (D. W. Dunstan et al., 2012; Levine, 2002, 2014). With today's information technology, designers have been successful in creating software and hardware applications that motivate users to break unhealthy habits such as prolonged sitting. Examples of such technologies are Runkeeper, Fitbit and Jawbone, which encourage users to take a break from everyday routines and engage in physical activity such as running or going for a short walk. Despite such successes, little has been done to incorporate such ideas into everyday life. One setting that accounts for many hours of sitting for adults is the office workspace. In the research described herein, I investigated this issue by taking a traditional human-centric contextual approach to HCI. By adopting a contextual approach to understanding modern offices, this thesis focuses on answering the following research question:

> *How can we approach the design of work in today's offices in order to make office workers more physically active in their workspaces?*

In order to address this question, this work was conducted within a cross-disciplinary team involving researchers from departments of Public Health and Clinical Medicine, Informatics and Umeå Institute of Design, in a project referred to as "*Increasing Physical Activity* (*InPhAct*)". More details about this project are presented in Part III. This thesis mirrors my experiences and reflections as a PhD student in the department of Informatics. My role in this cross-disciplinary project work was to explore ways to increase physical activity among office workers and break the habit of prolonged sitting by using Information Technology (IT). This focus on using IT to stimulate physical activity lead me towards a review of what has so forth been done in the area of Personal Informatics and Quantified Self systems. As was briefly stated in the introduction, contextual design provided a backbone and framework for tailoring the different methodological approaches to form a coherent research process. This research process helped me understand the context of work in relation to physical movements and helped me to address the research question.

My initial step in conducting the research described herein was to conduct a two-month long investigation recording how often members of a sports club in northern Sweden exercise to compensate for their sedentary lifestyle. In order to preserve the identity of the members of the sports club, in this thesis I refer to this case as the "*Sport Co.*". Subsequently I became interested in understanding the physical movements of office workers in the context of work, resulting in an ethnographic study. This study was conducted in the offices of a housing company in northern Sweden, referred to as "*Housing Co.*" The data that were gathered in the "*Housing Co.*" study were analyzed and reported to the team members. This ethnographic study provided the essential ideas for developing concepts and starting the process of building the first prototype, the "*NEAT Lamp*". The concept behind the "*NEAT Lamp*" was the result of a brainstorming session involving researchers from the Public Health and Clinical Medicine department, Umeå Institute of Design and me as a representative of the Informatics Department at Umeå University. Subsequently, the prototype system "*NEAT Lamp*" was evaluated in the second ethnographic study. The NEAT Lamp prototype is a USB-connected interactive system that provides an indication to the office worker that they have been sitting for more than 25 minutes. This final study was conducted in the offices of a healthcare company in northern Sweden and similarly in order to maintain their anonymity I refer to this study as "*Health Co.*". The "*Health Co.*" study resulted in the development of a conceptual framework for describing local movement and mobility and the design of the second prototype the "*Talking Tree*". With the use of several sensors located in different corners of the room the "Talking Tree" can detect movements within that space. The level of movement is quantified and when a threshold level is reached, the color of the plant's leaves changes. This second prototype was examined in a pilot study. Figure 1.3 illustrates the studies
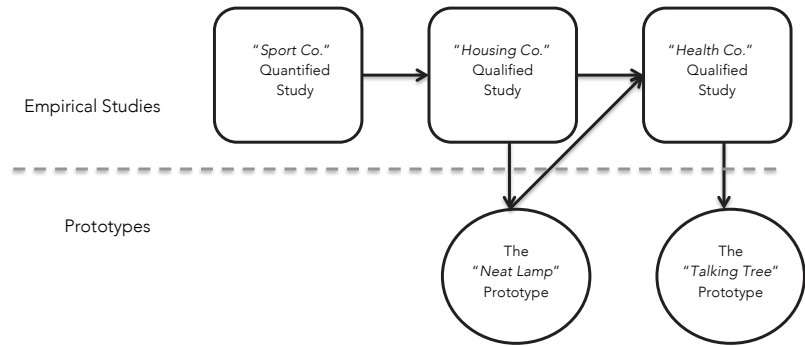
Figure 1.3. The process of the case studies and the prototypes made during this thesis work

conducted that together form the research underlying this thesis. More details about how the qualitative studies and the prototypes were designed and tested are presented in Part III. In addition to collecting empirical data and the conceptual work within the cross-disciplinary team, I wrote the five papers presented in this thesis. It is worth mentioning that the nature of our cross-disciplinary team had a significant role on how the research was conducted and on addressing the research question. The method developed during my research, along with the results of the studies, helped to reveal the local movement and mobility patterns of office workers. Finally, the knowledge gathered throughout the thesis work helped in understanding the context of work design in relation to bodies; this is discussed in the final section of "*Working Out Work*".

History as the Motive

A focus on work and work design is not related to the modern use of Information Technology in workplaces. On the contrary, the way work is executed has always been of interest to designers and technocrats (Cresswell, 2006). The history of work and work design has seen many changes over the centuries (Saval, 2014). In addition, our perspectives on work have also changed drastically. During ancient and medieval times, work was regarded as a curse (Hill, 1996). After the Protestant Reformation in the 16th century, a new perspective on work became widespread in which physical labor was considered acceptable even for the wealthy (Hill, 1996). Gradually, with the industrial revolution, the laboring body became the focus of attention and soon scientists and technocrats where investigating ways to train and discipline the body for physical work (Zuboff, 1988). With technological advancement, machines began replacing bodies and although the perception of hard work existed, the work force increasingly moved into office spaces (Barnes, 1953; Kvålseth, 1983; Shephard, 1974). With these changes in workplaces and particularly with the introduction of time and motion studies, other social shifts such as deskilling and reskilling and the separation of blue-collar workers and white-collar workers were created (Agnew, Forrester, Hassard, & Procter, 1997; Giordano, 1992). Decades later with the development of computer systems and Information Technology, work became more abstract than ever before and so the laboring body was shifted to a thinking body within the workspace (Zuboff, 1988).

Modern modes of employment have resulted in our bodies not being required to undertake physical activities in workplaces. (Zuboff, 1988). Being seated behind

a desk and doing office work confers a particular social status, that of being a white-collar worker (Saval, 2014). However, this disregard of bodies has created problems. Repetitive bodily movements result in muscle injuries and as this became more common, the field of ergonomics was established (Brookes & Kaplan, 1972; Shephard, 1974). However, carefully adjusting body movements within the work environment is not sufficient to prevent all the damage caused by work-related activities. For example, remaining seated for long periods is a known risk factor linked to many different illnesses (Katzmarzyk, Church, Craig, & Bouchard, 2009; Patel et al., 2010; Van der Ploeg, Chey, Korda, Banks, & Bauman, 2012).

It is estimated that, to date, more than 12,000 different careers are available and this list is changing everyday as new jobs appear and some old ones are no longer required. However, all of these shifts and changes in work design have had direct effects on the bodies of workers and so the history of work design has never been separated from the history of bodies in offices (Zuboff, 1988). The shift from the laboring body to the thinking body has resulted in prolonged sitting throughout our daily lives. In fact, being stationary and having a passive lifestyle is a result of our modern times (Cresswell, 2006). Studies indicate that the majority of our sitting time occurs in workspaces (Van der Ploeg et al., 2012). Therefore, there is a need to investigate this important consequence of the constant redesign of work that has occurred over the centuries. Focusing on bodies in workplaces has deep roots in the history of work design (Cresswell, 2006; Zuboff, 1988). However, this focus on bodies was mainly for the sake of work rather than workers, and targeted at increasing productivity and efficiency in the execution of work. We begin to notice bodies in workspaces in terms of their own good after we recognize the negative health consequences of work-related activities on our bodies. One such example is the emergence of the field ergonomics and human factors in the 19th century (Corlett, 1983; Shephard, 1974). Similarly, now that we have passive and stationary bodies in offices, many attempts have been made to increase physical activity without disturbing the process of work, as discussed later in this thesis.

Recently, public attention has focused on our bodies in workspaces, in particular our sedentary lifestyle in offices (Levine, 2002; Levine, Schleusner, & Jensen, 2000). According to studies, prolonged sitting is a risk factor in increasing all-cause mortality including type 2 diabetes, cardiovascular disease (CVD), certain types of cancer and non-CVD/noncancer mortality in adults (D. Dunstan et al.,

2010; Katzmarzyk et al., 2009; Patel et al., 2010; Van der Ploeg et al., 2012). Prolonged sitting includes all types of sedentary behavior which incur no more than 1.5 metabolic equivalents, such as sitting and lying down whilst, for example, working, eating and traveling (Van der Ploeg et al., 2012). Time spent sitting is associated with greater food consumption and therefore gaining weight, especially while watching TV (D. Dunstan et al., 2010; Patel et al., 2010). The majority of us have been adapted to a lifestyle where we are seated most of the time during our work, while eating our meals, when we are commuting and while resting and watching TV in our leisure time; therefore, sitting is our main activity at work, school and home. Sometimes we compensate for our sedentary behavior in one domain by sitting less in another, or by exercising after work (Van der Ploeg et al., 2012). However, it is not possible to compensate for prolonged sitting by occasional physical activity, even if this amounts to the current recommendations of public health organizations (Katzmarzyk et al., 2009). In the first empirical study I conducted in "*Sport Co.*", this fact was once again proven: that we as adults fail to reach the minimum recommendations of international organizations (see paper I). Therefore, there is an urgent need to revisit the design space of work in relation to the workers' bodies.

Step By Step: The Structure of this Thesis

So far this first part of "*Working out Work*" has briefly described the reduced physical activity of workers in workspaces – in particular in offices. In addition, I have briefly mentioned the problems associated with prolonged sitting and the health risks associated with it. In this regard, there is an urgent need to break the habit of prolonged sitting and encourage increasing physical activity among office workers within their work context. "*Working out Work*" investigates the context of work and its effect on bodies through the lens of HCI and contextual design. By applying contextual thinking along with a concept development mission in producing prototypes, I was interested to conduct intensive ethnographic studies and evaluate the prototypes in real work settings.

"*Working Out Work*" comprises a cover paper along with a collection of five individual papers. The cover paper is divided into five parts. Following this introduction, the second part summarizes related research on contextual design, the role of Informatics in offices and relevant designs in the field of Personal Informatics and Quantified Self. Part III starts by introducing the research project and is mainly devoted to the methodological approaches adopted, along

with a detailed description of the research process. To complete this research project, I tailored and adjusted the research process by combining and modifying three methodological approaches: ethnographic observational studies, prototyping and developing contextual concepts. The outcome of this research process was the design and implementation of two prototypes referred to as the "*NEAT Lamp*" and the "*Talking Tree*". Apart from the first quantitative study in "*Sport Co.*" I conducted two observational ethnographic studies in two companies ("*Housing Co.*" & "*Health Co.*") over more than six months. Part IV briefly outlines the findings of the two studies along with a summary of the five papers. Finally, in the last part of the thesis I return to the research question to discuss the new knowledge produced and the contribution of "*Working out Work*" for designing physically active workers in office spaces. In addition, the methodological implications as well as directions for further studies in this area are discussed. The appendix includes a number of pictures relating to the observational ethnographic studies and the questions used in the research interviews. Finally, the five papers are presented:

Paper I   Moradi, F., & Wiberg, M. (2013). Redesigning work–from sedentariness to activeness. *Procedia Technology*, *9*, 1005-1015.

Paper II   Moradi, F. (2016). Breaking Free: The Paradox of Bodies in Workspaces. Currently under review by an international journal.

Paper III   Moradi, F., & Wiberg, M. (2016). Getting It Going: Explorations at the Intersection of Moving Bodies, Information Technology and Architecture. In *Architecture and Interaction* (pp. 113-136). Springer.

Paper IV   Moradi, F., & Wiberg, M. (2016, July). Creating a Sense of Unity: From Quantified Self to Qualitative Space. In *International Conference on Universal Access in Human-Computer Interaction* (pp. 371-381). Springer.

Paper V   Moradi, F., Deshpande, P., Wahlström, V., Olsson, T., & Wiberg, M. (2016). A NEAT Solution: Where Interaction Design and

Public Health Meet. Currently under review by an international journal.

I was the first author of all the publications presented above. This indicates my role not only in the process of conducting the studies but also my leading role in initiating and undertaking most of the writing for these papers. The papers presented in this thesis provided different levels of contribution to this thesis work, and this is described in Part IV. These five papers include one single authored paper, three papers co-authored with my supervisor and finally a co-authored paper including all the team members of the project. Among these five publications, two have been submitted to international peer-reviewed conferences, the second paper was originally accepted as a workshop paper at CHI'14 and later it was further developed and extended in the form of a book chapter. Finally, the remaining two papers are manuscripts submitted to peer-reviewed international journals.

Part II:

From Office Informatics to
Personal Informatics
& back…

Introduction

The design and development of information systems has a noticeable role in shaping the offices of today (Kling, 1996a). The influence of Informatics in workplaces goes all the way back to the early days of computer systems and mainframes. In this thesis, for consistency, I refer to this use of informatics designs and computer systems in workplaces as "Office Informatics". This section provides a brief history from the early days of office informatics up to today's ubiquitous use of ultra-small computers and information systems known as Personal Informatics. Finally, this section describes the foundation for my studies of office work in relation to the office workers' bodies. In this regard, I chose to rely on a traditional way of studying offices, namely through observational ethnographic studies.

Throughout the years, with the development of computers, different movements have dominated the research field of HCI. These movements have been identified as being associated with three waves of HCI research (Bødker, 2006, 2015). Bødker (2006) states that the first wave was model-driven research based on cognitive sciences and human factors. The focus of this early research was on human beings; studies involved rigid guidelines, formal methods and systematic testing (L. Bannon, 1991). As Bannon describes, the move from human factors to human actors in HCI research is an indication of the shift from the first wave of HCI to the second wave (L. Bannon, 1991). This wave focused on collaboration among groups while interacting with applications in work settings. It was during this second wave that concepts such as "*context*" and well established theories such as situated action, distributed cognition, and activity theory came into focus (Bødker, 2006, 2015). Gradually other methods such as participatory workshops, contextual inquiries and prototyping were added to the list (Bødker, 2006, 2015). The current wave of HCI has broadened its focus and stepped away from designing only for work settings. Nowadays, computerization is not limited to work environments and interaction with computers is not only via a desktop; information systems have entered every aspect of our daily lives. New elements of human life such as emotions and experiences have been drawn into the interaction between humans and machines (Bødker, 2006). Therefore, research in the third wave focuses on understanding the emotions and experiences of the users through the use of cultural probes and other methods (Bødker, 2006). However, this wave of HCI research that has been discussed by Bødker (2006, 20015) and others such as Bannon (1991) has far more dimensions than this

short description. But I have used this categorization as a way to provide a logical structure for this part of the thesis.

Based on the distinction described above, this background section briefly mentions the related research of this thesis work. The first section of this part, "Office Informatics", discusses office automation and its vision and promises as one of the main fields of research in the first wave. Next, the second wave of HCI research is described, including the use of Computer Supported Collaborative Work (CSCW) in establishing work. Prolonged stationary behavior of office workers has encouraged different researchers from various fields such as Public Health scientists to come up with various designs and interventions (Levine, 2015). At the same time, with the third wave of HCI, there have been many designs dealing with passive bodies in different contexts [see e.g. (Burns et al., 2012; Consolvo, McDonald, et al., 2008; Foster et al., 2010; Jafarinaimi et al., 2005; Lin et al., 2006)]. Therefore, the passiveness of modern bodies has encouraged designers to attempt to encourage users to adopt healthier behaviors and motivate them to increase their physical activity (Ploderer et al., 2014; Swan, 2012). These attempts and visions in recognizing the role bodies in design are described in detail at the end of this Part.

The First & Second Waves of HCI: Office Informatics – from Mainframes to Laptops

In the 1950s, when huge room-sized mainframes were introduced to the public, journalists called them *"giant brains"* (Kling, 1996c). Nowadays we carry smart phones and wear watches that have far more computational power than those *"giant brains"*. Computing technologies have dramatically changed over the past seven decades and our society has been transformed with it (Kling, 1996a). One of the first domains where information technology was utilized was workplaces and organizations and this use continues today (see Figure 2.1). With the introduction of computer-based technology to offices, the abilities of workers and organizations were soon amplified in amazing ways (Kling, 1996d). The effect of computerized systems in offices could be compared to the role of steam engines during the industrial revelation (Kling, 1996a). However, despite the positive changes associated with computerization, these were accompanied by social problems and controversies (Kling, 1996a). Such controversies included: the economic role of computerization, the nature of the working life, class divisions

in society, democratization, gender biases and health and wellbeing (Kling, 1996d). These challenges encouraged researchers to investigate the context of work and find ways of organizing it. At the same time, this growing use of information technology in offices provided a suitable foundation upon which to conduct studies and speculate about the effects of computerization at work. Thus, Informatics has a long tradition of studying the context of work from a human-centric perspective with classical examples such as Rob Kling's studies in understanding computerization and its controversies (Kling, 1996a) and Lucy Suchman's ethnographic studies in understating situated actions (Suchman, 1987). This contextual investigation in workplaces was carried on for decades while investigating CSCW (Blomberg & Karasti, 2013).

Figure 2.1. An example of using Informatics in offices today, "*Office Informatics*"

The First wave of HCI: Office Automation

Office work has always been associated with keeping records (Saval, 2014). In the 1960s when large businesses adopted computer-based information systems, besides enhancing efficiency, there were other changes shaping organizations (Kling, 1996a). As soon as there was a rapid increase in the use of computerization in offices, there was a growing body of studies investigating this event (Hirschheim, 1986b; Kling, 1996a; Zisman, 1978). In this regard, Zisman (1978) describes, the term "*Office Automation (OA)*" in detail. He mentions that OA is a relatively old term, used in the late 60s to refer to the use of computers to structure high volume office tasks such as payroll and processing. Later, during the late 70s "Office Automation" referred to the application of computer technology and there was less focus on structuring office functions. However, in both cases, the object of OA was to improve the productivity of white-collar workers (Zisman, 1978).

There was widespread agreement among OA researchers about the marked and pervasive effects of computerization in offices. However, as is obvious from the literature, there was a slight disagreement about what these effects might be, and thus there were views on the implications of "*Office Automation*" (Hirschheim, 1986a). Some viewed these changes positively as a way of bringing the office into the twentieth century and improving productivity, quality of working life, communication and job satisfaction, whereas others were more skeptical and voiced concerns about deskilling, personal privacy and a general degradation of the quality of work life (Olson & Lucas Jr, 1982). In a thorough investigation by Hirschheim (1986a), the different views on OA were outlined and he underlined the theoretical perspectives and philosophical roots behind the alternative views of computerization in offices (Hirschheim, 1986a). Regardless of the different perspectives, the fact was that computerization in workplaces made managers and workers better able to handle certain tasks (Olson & Lucas Jr, 1982).

In one well-known classical textbook, Rob Kling (1996) investigated computerization and the controversies it created in workplaces. Kling mentions major changes in workplaces such as a shift in control to the central administrators, the way work is organized, and an increase in jobs mostly filled by women. Shifting from pens, ink, and paper as office equipment to primitive typewriters and later to other office machines such as telephones and punch-cards, were the first steps towards automated offices (Kling, 1996a). With the arrival of computer terminals, photocopiers and word processors, mechanical automated offices seemed old fashioned and today it seems we have become even more automated. Offices are becoming increasingly paperless and computers and other information systems are replacing them. Therefore it is important that office environments improve in general, as sensitivity to occupational hazards grows (Kling, 1996a). One of the most obvious hazards of office work today is prolonged sitting in front of computers and information systems.

The Second *Wave of HCI: Computers Supporting Collaboration at Work*

It was not until the late 80s and early 90s that researchers came to recognize computerization in offices as a tool for supporting cooperative work. The term "*Computer Supported Cooperative Work (CSCW)*" refers to a computer-coordinated activity carried out by a group of collaborating individuals for communication, problem-solving or learning (Baecker, 1992). CSCW was considered a design-oriented field with an interdisciplinary perspective aimed at identifying characteristics of group work for designing technology appropriate for supporting cooperation (Bødker, 2006). However, CSCW studies are not limited to the design of such technologies, they also investigate the impact of similar systems on office workers and organizations. Like the notion of "*Office Automation*", there is much controversy over the definition of "*Computer Supported Cooperative Work*". Discussing these differences, however, is beyond the scope of this thesis.

The use of information technology in offices and the support it provides faced a new challenge with the advent of mobile computing. Various researchers became interested in investigating different aspects of mobile technology in relation to ways of conducting work (Dahlbom & Ljungberg, 1998; Kristoffersen & Ljungberg, 1998; Wiberg, 2001). The term "*Mobile Informatics*" was coined by Dahlbom & Ljungberg (1998) in the late 90s and they explored the services and concepts of mobile IT use at work. "*Mobile Informatics*" sounded very promising in breaking the traditional boundaries of office work. Hand in hand with the invention of the Internet, it was thought that office workers would soon be leaving their desks and would become mobile (Dahlbom & Ljungberg, 1998). Therefore, researchers considered it necessary to develop new frameworks for mobile informatics, expecting that workers would abandon models developed for stationary computing in offices. One example of such conceptualizations is the three different modalities of mobile IT use in offices introduced by Kristoffersen and Ljungberg (1998):

1. Wandering (office workers' local mobility in the workplace),

2. Travelling (office workers' movement from one place to another by vehicle),

3. Visiting (office workers spending their time in a third location away from the office).

Although the use of mobile IT provided the ability to step outside the geographical boundaries of a traditional office, the stationary nature of office work has remained. In fact, office work is very much about stationary work and more than 15 years later we still have the same configuration. Therefore, in this thesis, I investigate ways of increasing physical activity among office workers given this configuration.

The Third Wave of HCI: Computers Everywhere

As mentioned in the introduction, the pervasiveness of computers in daily life encouraged HCI designers to abandon traditional ways of creating interaction between users and computers. Interaction with computers was no longer limited to desktops and so new ways of designing Information Systems were suggested. Apart from the contextual changes that computers were facing, new functions and applications needed to be developed and designed (Bødker, 2006, 2015). New objectives such as investigating User eXperience (UX), emotions and aesthetics became the intention behind the third wave of HCI research. This last wave is indeed very broad both in terms of the contexts of the studies and also the variety of intentions and designs (Bødker, 2006, 2015). Here, I focus on concepts and movements that specifically target the passive bodies in workspaces, as it is the interest of this thesis. Embodied interaction is one of the foundation stones when designing for bodies in the "*post-desktop*" era – a term used to describe the modern era of pervasive computing systems (Kaptelinin & Czerwinski, 2007). Later, I discuss a fairly recent movement known as Personal Informatics (PI) (Kamal et al., 2010; Li et al., 2010) or Quantified Self (QS) (Swan, 2012) which serves its users by collecting and visualizing personal information in order to encourage reflection on actions adopted by the user. These systems are possible because of advances in sensor technologies and the availability of ultra-small computers, which are used in many contexts: from recording the number of the steps taken each day, to monitoring your finances and even the quality of your sleep (see: http://quantifiedself.com/guide/). However, in this section the focus is on the design of PI systems that deal with

increasing physical activity and from there I explore various designs and interventions.

Embodied Interaction: Embracing both Body & Brain

Our bodies play a key role in understanding and experiencing the world around us. In fact, contrary to Descartes' view, our mind is evolved through the interplay of our bodies with our brain (Damasio, 1994). During the first and second waves of HCI, research focused on designing interaction via desktop computers. These attempts, which were mostly applied in the context of work, resulted in work processes and procedures shifting from laboring bodies on factory floors to thinking bodies (Zuboff, 1988). With today's ubiquitous application of technology there is an opportunity to move about and simultaneously interact with our computer systems. This new approach to interaction design requires in-depth investigation to determine the tradeoff between users and computer systems. "Embodied interaction" refers to a way of designing interaction that takes account of social and physical reality and exploits the ways that they interact with us (Dourish, 2004b). Others researchers, such as Bødker and Klokmose (2011), have described this post-desktop computing approach as a way to see ourselves embodied in technology and to consider how our physical capacities extend and expand through technology. Drawing the focus of interaction towards the everyday world, Dourish starts by exploring tangible and social interaction as important elements that exploit our familiarity and facility to interact with the world. Embodiment as defined by Dourish is derived from a phenomenological perspective, where individuals are defined by the tools they use (Dourish, 2004b). However there are other terms describing the same phenomena such as "equipment" or "functional organs" (Bødker & Klokmose, 2011). Such theories of bodily engagement in the world inspire new interaction design approaches to achieve better integration between the physical and computational worlds (Klemmer, Hartmann, & Takayama, 2006). For interactive designers, interaction is intimately connected with the settings in which it occurs. Therefore they use anthropological methods to facilitate a deeper understanding of both the physical and social aspects of the environment (Klemmer et al., 2006). This focus on the setting encourages them to consider work activities and physical artifacts rather than merely abstraction of the processes. In addition,

there has been a recognition of the role of embodiment with respect to artifacts that we interact with on a daily basis (Dourish, 2004b).

Personal Informatics: Presentation of Data for Self-Reflection

The effects of pervasive computer systems are not limited to how we perceive interaction in the post-desktop era. With the use of widespread sensor technologies and ultra-small computers there has been a growing interest in designing systems that could be used as a persuasive force to support behavior change in everyday life (Fogg, 2002). Such systems are known as persuasive technologies (Consolvo, Everitt, Smith, & Landay, 2006; Consolvo, McDonald, et al., 2008; Fogg, 2002; Jafarinaimi et al., 2005). Various personal and ubiquitous computing systems have been employed to help users to achieve their goals and change their behavior (Ploderer et al., 2014; Swan, 2012). These systems range from smartphone applications and wearable devices to sensors and embodied displays in the environment (Ploderer et al., 2014). The idea of designing computer systems for encouraging behavior change was originally introduced in BJ Fogg's book on persuasive technology (Fogg, 2002).

Many of these systems focus on health aspects of the users, encouraging them to engage in physical activity, or adopt a healthier diet, or therapy to counter depression, or abandoning unhealthy habits such as smoking (Swan, 2012, 2013). These systems have also been used in the area of sustainability to aid users in households and workplaces to reduce their electricity or water consumption and motivate them to recycle waste (Ploderer et al., 2014). In addition, recent designs have addressed more routine daily activities such as organizing household chores, finances and even time spent watching TV (Ploderer et al., 2014). Despite all the different contexts, this thesis focuses on those systems that encourage physical activity and breaking the habit of prolonged sitting particularly in office settings. Another area of technological design that has been involved with increasing physical activity is computer games. The early attempts to combine health and video games date back to 1982 by Atari Crop (Mokka, Väätänen, Heinilä, & Välkkynen, 2003). In this thesis I focus on investigating ways for office workers to be more physically active in the context of everyday work rather than on exercise activities.

In fact, many designs have explored ways to encourage individuals to break the habit of prolonged sitting in desk-based jobs. One of the early examples of such designs is Breakaway, which reflects the form and the shape of the human body (Jafarinaimi et al., 2005). This ambient display (Ishii & Ullmer, 1997; Ishii et al., 1998), inspired by the principles of calm technology (Weiser & Brown, 1996), reminds the user that they have been sitting for too long and need to go for a short walk (Jafarinaimi et al., 2005). Bearing in mind the principles of calm technology, designing such a display is a thoughtful way to convey the message without creating extra focus or attention (Weiser & Brown, 1996). The use of ambient or other stylized forms of display to represent physical behavior is one common approach when designing such systems. One of the early designs for using a computer screen as a display for representing the number of the steps taken by the individual and their colleges is Fish 'n' Step (Lin et al., 2006). With the use of step counters carried by the office workers, the virtual fish pets in the display represent their user's activity levels and the activity levels of their teammates. In addition, other forms of ambient displays in the form of wearable technology have been used, for example ActivMON (Burns et al., 2012). The popularity of using ambient displays in encouraging behavior change has been the aim behind many studies (Forlizzi, Li, & Dey, 2007; Hazlewood et al., 2011; Rodgers & Bartram, 2011). Other attempts have considered the use informative art as a way of displaying physical activity (Fan, Forlizzi, & Dey, 2012).

Apart from ambient and ubiquitous displays for encouraging behavior change, many other designs have used mobile screens to represent daily physical activity and encourage users to increase their levels. One of the early designs in this field was Houston, a prototype of a mobile phone application for encouraging activity involving the use of step counting among friends (Consolvo et al., 2006). Subsequently, many similar prototypes have been developed, including Shakra (I. Anderson et al., 2007) and UbiFit (Consolvo, Klasnja, et al., 2008). With the popularity of social media, gradually the idea of connecting pervasive technology in order to increase the effect of changing habits is becoming a common practice. Prototypes like StepMatron (Foster et al., 2010) or Recipe Box (Kamal et al., 2010) were among the first examples of such attempts.

The idea of life logging and managing personal data has been around since the early days of wearable computers (Sellen & Whittaker, 2010). However, the idea of using such personal data to encourage behavior change is a more recent notion. A number of studies have attempted to develop strategies for creating
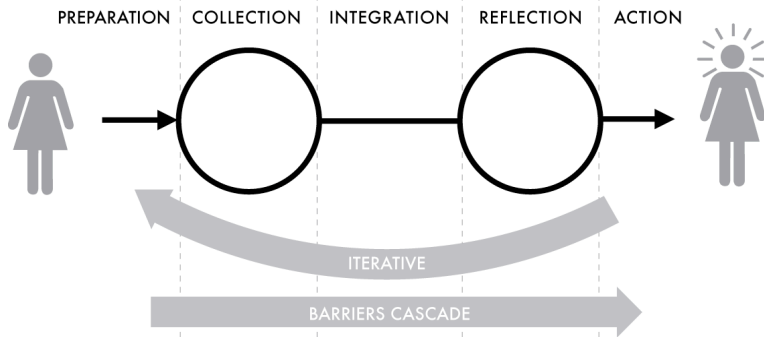
Figure 2.2 The Stage-Based Model of Personal Informatics Systems Presented by Li, Dey, & Forlizzi (2010)

technologies that support behavior change (Consolvo, McDonald, & Landay, 2009; Li et al., 2010). In a paper presented by Li et al. (2010), a stage-based model was presented to describe this class of systems known as Personal Informatics (PI). The notion of Personal Informatics that was coined in this paper refers to all hardware and software technologies that collect personal information and use them to change behavior by presenting this data. In this model, five main steps were identified: preparation, collection, integration, reflection and finally action (Li et al., 2010).

The popularity of Personal Informatics (PI) systems has not been limited to academic studies and prototypes. In fact, many self-tracking devices have recently been introduced to the market including Fitbit, my Zeo, BodyMedia, MapMyRun, RunKeeper, MoodPanda, Nike +Fuelband, The Eatery and Jawbone (Swan, 2012). The pervasiveness of such devices has resulted in the Quantified Self (QS) movement. Quantified Self as one of the key contemporary emerging trends of big data has been the subject of many papers (Lupton, 2014a, 2014b; Swan, 2012, 2013).

Currently, the topic of Personal Informatics and Quantified Self is still being investigated from different perspectives: from the sociological perspective (Lupton, 2014a, 2014b) to the psychology of well-being (Karapanos, Gouveia, Hassenzahl, & Forlizzi, 2016); from a critical examination of reflection in such systems (Pirzadeh, He, & Stolterman, 2013) or even a phenomenological understanding of Personal Informatics systems (Ohlin & Olsson, 2015) to architectural perception of ambient displays when used as a PI system (Moradi & Wiberg, 2016a). Investigating Personal Informatics systems and self-trackers in a way that fosters more meaningful experience has also been suggested in handful

of recent studies (Elsden, Kirk, Selby, & Speed, 2015; Karapanos et al., 2016; Swan, 2012).

Part III:

Tailoring a Contextual Method

Introduction

Scientific methods are a body of techniques for investigating phenomena and acquiring knowledge (Patton, 1990). In this regard, qualitative research inquiry is a process of meaning-making. Patton (1990) describers qualitative research as follows:

> "*Psychometricians try to measure it. Experimentalists try to control. Interviewers ask questions about it. Observers watch it. Participant-observers do it. Statisticians count it. Evaluators value it. Qualitative inquirers find meaning in it.*"

So far in this thesis I have mentioned the crucial role of using contextual design as the backbone of the research. To optimize the contextual design principles of the research project, I adjusted and tailored my research process. Specifically, I used three different methodological approaches to conduct my four-year contextual design research project. The three methodological approaches employed were observational ethnography, concept development and prototyping and they have been woven together and applied at different points in the research process. Before expanding on this process, I wish to introduce Increasing Physical Activity (InPhAct), the cross-disciplinary research project upon which this thesis is based.

The Increasing Physical Activity (InPhAct) Project

As mentioned earlier, in recent years clear evidence has been presented showing that sedentary behavior can increase the risk of obesity and various diseases (D. Dunstan et al., 2010; Katzmarzyk et al., 2009; Keim, Blanton, & Kretsch, 2004; Patel et al., 2010; Van der Ploeg et al., 2012). According to health recommendations not only encouraging physical activity but also discouraging sedentary behaviors can have positive effects in reducing the associated risks and have a positive effect on the physiology of weight change (Bergman et al., 2015; D. W. Dunstan et al., 2012; Keim et al., 2004; Levine, 2004; Levine et al., 2000). Various strategies have been adopted to create active workplaces. These include: workload planning (e.g. interspersing sedentary and non-sedentary tasks), environmental changes (e.g. using treadmill desks, relocating stairways, moving

printers away from desks), moving work tasks (e.g. walking meetings) and encouraging physical activities (e.g. periodic breaks, walking/exercise groups) (Gilson, Burton, Van Uffelen, & Brown, 2011). Nonetheless, the immobile workers in today's offices are the result of constant redesigning of workspaces, resulting from a desire to increase productivity and efficiency (Cresswell, 2006; Moradi & Wiberg, 2013; Zuboff, 1988). Therefore, to create sustainable change we should adopt a cross-disciplinary approach to the phenomena associated with today's stationary work. Recent studies have, indeed, noted the importance of taking a multiple disciplinary approach to tackling our sedentary lifestyles (Kohl et al., 2012; Levine, 2015). Increasing Physical Activity (InPhAct) is a cross-disciplinary research project that is a collaboration between the Department of Public Health and Clinical Medicine, Informatics, Architectural school of Umeå University and Umeå Institute of Design. InPhAct aimed to investigate ways to increase physical activity and break the habit of sedentary behavior among office workers. As highlighted in previous studies, becoming accustomed to repetitive bodily movements at work is a result of more than two hundred years of deliberate design (Cresswell, 2006; Zuboff, 1988). This has resulted in changes in the design of architecture, interiors and machinery for homes and workplaces (Cresswell, 2006; Das & Grady, 1983; Kvålseth, 1983; Shephard, 1974). Therefore, increasing physical activity should not be limited to the domain of public health studies. We require a more holistic view of this complex phenomenon rather than treating inactivity among office workers as a behavioral science issue focusing only on individuals (Kohl et al., 2012). Thus, InPhAct investigates this complex phenomenon from a cross-disciplinary perspective, from Public Health to Interaction Design and Informatics.

Is it true that "Sitting is the New Smoking"?

In recent years there has been a growing concern about the risk factors associated with the stationary lifestyle both at home and in workspaces. Some have even referred to this with the phrase "*sitting is the new smoking*" (Yoder-Wise, 2014). Indeed, obesity is becoming a major health issue in our modern society and so increasing movement in our daily lives and assigning a number hours per week to physical activity are recommended (Van der Ploeg et al., 2012). It is estimated that our modern inactive lifestyle accounts for 6-10% of deaths from non-communicable disease worldwide (Kohl et al., 2012). According to the World Health Organization, adults aged 18 to 64 require at least 150 minutes of moderate or 75 minutes of vigorous intensity exercise each week to

improve cardiorespiratory and muscular fitness and reduce the risk of non-communicable diseases and depression (World Health Organization). However, available data suggest that 31% of the world's population do not meet the minimum recommendations for physical activity (Kohl et al., 2012). In the first quantitative study, conducted in the "*Sport Co.*", I investigated data logs from one of the biggest sports clubs in Northern Sweden. In this study, it became evident that the study group exercised for only one third of the time recommended by the World Health Organization (Moradi & Wiberg, 2013).

NEAT-ly Done: A Pathway for Increasing Physical Activity

As mentioned earlier, increasing physical activity with the target of breaking the habit of prolonged stationary behavior is the core of the InPhAct project. In recent years it has become apparent that regular physical activity within the context of everyday practices yields health benefits (Keim et al., 2004; Levine, 2004). Existing research indicates that Non-Exercise Activity Thermogenesis (NEAT), which refers to any physical activity other than sport-type exercise, including work-related activities, has a direct effect on the physiology of weight change (Fujiki et al., 2007; Levine, 2004). Levine et al. described NEAT as an important factor for gaining weight and they stated that obese individuals have the tendency to remain seated for 2.5 hours per day more than lean individuals (Levine, Eberhardt, & Jensen, 1999; Levine et al., 2005). Therefore Levine and his colleagues proposed placing treadmills in offices as a tool to decrease sitting time and increasing NEAT (Levine et al., 2000). Although this solution is considered an effective way to make environmental changes, efficient and silent treadmills are expensive and require substantial space (McAlpine, Manohar, McCrady, Hensrud, & Levine, 2007). Later, in order to increase NEAT in the modern lifestyle, and as a motivation for users to change their everyday habits, they developed NEAT-O Games, a collection of cellphone games (Fujiki et al., 2007).

In a recent study published by Levine (Levine, 2015), office workers are categorized into three groups based on their energy expenditure levels at work. In this classification, the first type is referred to as the *chair-locked worker*, a seated person working at their computer. This class of office workers generally uses only 5% above basal energy expenditure, approximately 10-20 kcal/h. The

second type, known as the *NEATthusiasts worker* is a person who doubles their energy expenditure by spending some minutes standing or walking. An average person walking at a speed of 1.6-3.2 km/h will expend 100-250 kcal/h above the basal energy expenditure. The office workers referred to as *NEATthletes* are the final group, who can increase their energy expenditure to 1,000 kcal in comparison to the first group while having the same desk-based job but by partaking in walking work meetings, having a chair-less desk, taking short walks during lunch time and cycling to work.

As stated, short active NEAT breaks can have a significant effect on the daily energy expenditure of the office workers. Subsequently, a number of researchers have suggested break programs for interrupting sedentary work (Taylor et al., 2013). "*Booster Break*" is an organized, work routine that was designed to interrupt prolonged siting with the aim of improving physical and psychological health (Taylor et al., 2013). Although "*Booster Break*" was successful in reducing stress and promoting enjoyment, improving health awareness and behavior change, and enhancing social interaction, the routines were described as being repetitive and it required significant management support (Taylor et al., 2013). Other individual approaches include computer break software programs. Most of these programs lack an efficient usable interface and can be repetitive, giving messages every now and then. For example, "*CAA*" is a free widget developed by the Chiropractor's Association of Australia that assists computer users in general and office workers to sit correctly and maintain their posture (Chiropractors' Association of Australia, 2016). In a study testing similar computer applications, participants indicated that they were not aware of the harmfulness of sedentary behavior and that the lack of control is seen as a large source of annoyance with PC break applications (Geleijnse, Van Halteren, & Diekhoff, 2011).

As mentioned previously, there have been a number of workplace interventions in offices (Gilson et al., 2011). However, in a review by Straker et al., a number of workplace interventions were criticized due to the lack of any significant decrease in the overall sitting time (Straker, Abbott, Heiden, Mathiassen, & Toomingas, 2013). They emphasized the importance of appropriate education for successful use of adjustable furniture such as sit–stand desks. Finally, they conclude the paper by indicating that for sustainable interventions to be effective in the workplace, there is the need for more than just technology and education/awareness. The interventions and the design should be embedded in behavior change theory (Straker et al., 2013). However, a number of recent

studies have emphasized the need for a cross-disciplinary approach when it comes to increasing NEAT among office workers rather than simply focusing on behavior change theory, which mainly addresses individuals (Kohl et al., 2012; Levine, 2015).

Contextual Design as the Backbone of the Research Process

As noted previously, HCI research developed in three waves as described by Bødker (Bødker, 2006, 2015). These three waves are distinguishable in terms of using different theories and methods. During the first wave, research was model-driven and methods were formal with rigid guidelines (Bødker, 2015). Gradually such traditional predictive research techniques were found to fall short with respect to delivering timely and relevant design information (Wixon et al., 1990). At the 1989 CHI conference, several sessions were devoted to non-traditional design techniques. Various non-traditional methods were described, for example "*Usability Engineering (UE)*" (Nielsen, 1994; Whiteside & Wixon, 1987), "*Artifact Examination (AE)*" (Carroll & Kellogg, 1989) and "*Contextual Design (CD)*" (Beyer & Holtzblatt, 1997; Wixon et al., 1990). Both UE and CD focus on understanding the user's needs in context, in contrast to AE. However, UE differs by emphasizing enhanced usability. On the other hand, artifact examination uses a task analysis approach which is not in the other two methods (Wixon et al., 1990). Although the emphasis on context was initiated in the second wave of HCI research, the notion is still being explored in the third wave of HCI while investigating ubiquitous computing (Weiser, 1991), context-aware computing (Abowd et al., 1999), pervasive computing (Ark & Selker, 1999), embodied interaction (Dourish, 2004b) and other approaches (Dourish, 2004a). With context being an important factor in HCI research, I have based my methodological approach around the principles of contextual design.

This third part of the thesis starts by describing contextual design. While tailoring and adjusting the research process, I have been inspired by the main principles of contextual design. Thus, contextual design has functioned as a backbone for my research supported by three methodological approaches, namely observational ethnography, concept development and prototyping. As mentioned earlier, in this thesis I refer to this adjustment as tailoring. In this section, the relationships between the three methodologies, as a way to expand

our understanding of the context of bodily movement in office spaces, are described in detail. Figure 3.1 elucidates the process I used when conducting this study. The first step was to conduct an intensive observational ethnographic study. By conducting such observational studies, I gained an insight into physical movement in modern offices. However, to move beyond this contextual understanding, there was a need to bridge the gap between the knowledge gathered from the ethnographic studies and design. Behind the development of each artifact lies a concept that is delivered through the design. Therefore, the knowledge gathered in the observational ethnographic studies provided the opportunity to develop concepts. On this note, similar approaches such as concept driven design (Stolterman & Wiberg, 2010) and strong concepts (Höök & Löwgren, 2012) were used as a guide for concept development. Subsequently, to evaluate the approaches and expand my knowledge of the context of bodies in office spaces, these concepts were applied within the design of two prototypes: "*NEAT Lamp*" & "*Talking Tree*".

Contextual Design: A Way to Understand and Design

Contextual design is a state-of-the-art approach to designing products in which product ideas emerge from the designer's deep understanding of the user's need and the user's understanding of the possibilities presented by the technology (Beyer & Holtzblatt, 1999). Ironically, contextual design is a customer-centered approach for finding how people work and ultimately discovering optimal ways of redesigning work (Beyer & Holtzblatt, 1997). Mostly this approach has been used to redesign work processes, but in this thesis my focus is not on providing change with respect to the process of work, but instead on how to redesign work to encourage physical movement in workplaces. Having the human-centric perspective in HCI research makes us concerned about the context of work and this motivated me to incorporate cooperation into design (Mathiassen, 1997) throughout the work underpinning this thesis.

Contextual design explicitly provides steps with measurable deliverables optimized for large-scale projects as well as small projects (Beyer & Holtzblatt, 1997). Having explicit steps makes the team members aware of each other's actions and provides the opportunity to think and share throughout the process.

These so-called parts of contextual design are as follows (Beyer & Holtzblatt, 1997):

I.   Contextual Inquiry: Talking and gathering information from individuals in their workplaces while performing work. This step will reveal implicit details and motivations for people's work, makes the work needs real for the designers, provides data as a base for decision-making and through the data collected provides a shared understanding.

II.   Work Modeling: Creating a model based on inquiries conducted in the first step. Such models can provide a common language about the work among the team members, present the work structure based on the data collected and provide a foundation for team conversations based on explicit representation.

III.   Consolidation: Creating a single statement of the work based on the common approaches of different individuals. This step provides a coherent map of the individual's perception of the work process, which can reveal a vast amount of qualitative data quickly. This map identifies customer needs and shows the underlying structure of work among different units; this collated data can be used in future projects.

IV.   Work Redesign: Inventing and developing better ways to work. This stage focuses on how to improve work by collecting and integrating ideas from the whole team.

V.   User Environment Design: Representing the entire system in terms of planning, marketing, User Interface design and other specifications. Throughout this step we can maintain coherence for the system and capture the structure, flow and function of the system. This step focuses the design on the whole system and provides an opportunity to plan and keep the team members concentrating on the process.

VI.   Mockup and Test with Customers: Testing and iterating the design with the customers through the use of paper mockups. Implementing this step means that defining and fixing errors with the new design is straightforward and it provides the opportunity to include the users in the process of developing the new system. Other advantages of this

stage include resolving disagreements within the team and avoiding arguments.

However these steps are not necessarily consecutive (Wixon et al., 1990) and each individual step can be shortened or omitted if they are not applicable; similarly, a step can be elaborated with additional techniques if appropriate (Beyer & Holtzblatt, 1999). This unusual characteristic of contextual design provides the opportunity to tailor the approach to the process at hand (Beyer & Holtzblatt, 1997, 1999). Contextual design provides a framework for challenging and developing the design process without losing the focus of the study (Wixon et al., 1990). If adopting contextual design in a project, the first step is to define the design process so that it best suits the situation. In designing the process the key is applying contextual design thinking. In fact, as Beyer and Holtzblatt (1997) stated, "*The nature of the design problem determines the best design process*".

For a design problem similar to the one that I pursued in this research, there was a need to develop a new process. The context of this thesis work is offices, and indeed these were the target of the first and second waves of HCI. The difference with this thesis lies in the research question, in which the focus of the change is not the process of work but the physical movement of office workers. Only passive bodies have been investigated in the third wave of HCI, so despite the familiar context, a unique research process was required. Throughout the process, the main steps of contextual design that were applicable to the design problem were employed. *Contextual inquiry* & *work modeling* were conducted in an observational ethnographic study; *consolidation* was applied throughout the process, resulting in a framework describing local movement and mobility (see the Results section). *Work redesign* was achieved in a brainstorming session in which concepts were developed; *user environment design* started with pilot studies and finally a mockup *and testing* was achieved by prototyping in the actual setting while undertaking the second ethnographic study. During this research process, the main three principles of contextual design – gathering user data, playing and communicating in the team and employing design thinking (Beyer & Holtzblatt, 1997) – were all applied. Therefore, contextual design created a backbone for the research process and provided a framework applied to all the steps of the process. In the following section the research process adopted in this thesis is described in detail.

The Research Process: Ethnography, Concept Development & Prototyping

The research process was tailored specifically to the work described herein. Three methodological practices, namely observational ethnography, concept development and prototyping, were used in the process to assist in understanding the context. These helped me to articulate different steps of the contextual design. Although each one of these practices can represent a complete method of investigation in its own right, in my research they were tailored and woven together to create a coherent contextual design process, as illustrated in Figure 3.1. Furthermore, each phase in this research process has been mapped to the six steps of contextual design as described in the previous section.
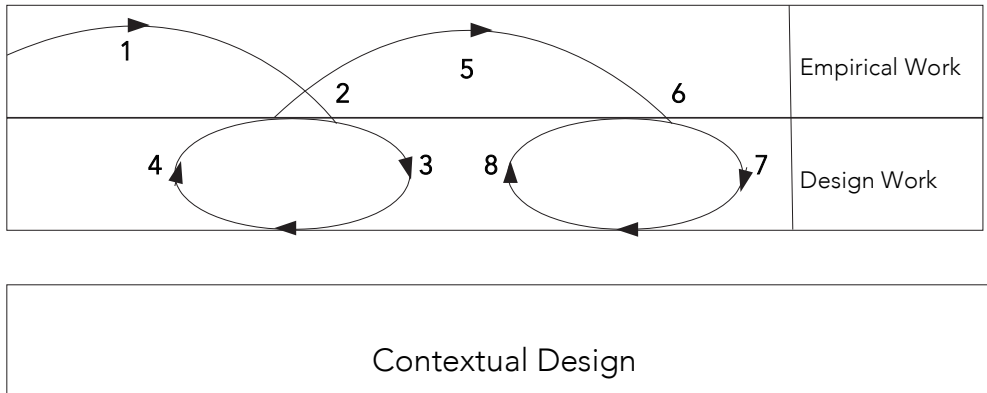
Figure 3.1. An illustration of the research process adopted in this thesis work

The figure above represents the research process starting from the top left corner which represents conducting empirical work in the form of an observational ethnographical study. Gradually the process moves to the border between empirical work and design work where the design concept was developed and the process moves to the design work. After the design work has been completed, the process moves back to the second empirical study. The second empirical study was similar to the first but also involved an observational evaluation of the first prototype. The outcome of this empirical work resulted in the concept being further developed and inspired the team when designing the second prototype.

The illustration above identifies eight different key phases in the research process. In this section I briefly describe the actions taken in each one of these phases and how the actions taken in each relate to the different steps of the contextual design. Following this section, I provide a detailed description of how ethnography, concept development and prototyping were applied in the research process.

1. The first action that was taken in this research was an observational ethnographic study in a housing company in northern Sweden, lasting almost three months. Herein this is referred to as the "*Housing Co.*". In this empirical work the aim was to develop an understanding of the context of work and local movement and mobility among office workers. The aim of my research is to find ways to break the habit of prolonged sitting among office workers and encourage increased physical activity within the office space. During this study I made field notes and occasionally I conducted informal interviews with the office workers. In addition, photos were taken and I sketched the everyday patterns of local movement among the office workers. This first milestone of the design process was inspired by the two first steps of the contextual design, namely, "*contextual inquiry (I)*" and "*work model (II)*".

2. In the final weeks of the "*Housing Co.*" study, our team, including researchers from the Public Health and Clinical Medicine field and Umeå Institute of Design, along with myself, gathered for a brainstorming session. Applying conceptual thinking to design from the early days of the research process and with the help of this session we were able to develop the "*NEAT Lamp*" concept. This concept was used in the design of the first prototype the "*NEAT Lamp*". This concept perfectly suited the nature of the problem we were facing. This stage maps onto the fourth step of the contextual design process known as "*work redesign (IV)*".

Note that the third step, "*consolidation (III)*", was a continuous procedure for me during the research process. As a result, it would be difficult to assign it to a particular phase in the process. My initial attempts to create a coherent map to explain local movement and

mobility of office works started towards the end of the first observational ethnographic study and continued during the rest of the research. The first evidence of such attempts can be seen in paper II and finally in paper V there is a framework explaining the phenomena associated with movement and mobility among office workers in office settings.

3. In the third phase, the first prototype the "*NEAT Lamp*" was developed. Two "*NEAT Lamp*" prototypes were initially designed. It is worth mentioning that, unlike the procedure in the contextual design protocol, both versions were hi-fi prototypes.

4. The prototypes were real objects and they were pre-tested before conducting a full user evaluation. In order to investigate whether the design suited office workers, a pilot study was conducted with one of the versions of the lamp for a month. In this short study one of the office workers from the department of Informatics, Umeå University volunteered to test the lamp and her feedback was essential to the final design of the "*NEAT Lamp*" prototype. This step can be equated to "*user environment design (V)*" (Beyer and Holtzblatt, 1997).

5. After finalizing the design of "*NEAT Lamp*", this prototype was evaluated by six volunteers in the actual setting during my second observational ethnographic study. This study was conducted for almost three months in a healthcare company in northern Sweden. Herein this company is referred to as "*Health Co.*". The second observational ethnographic study extended my knowledge of the context of movement and mobility among office workers. Moreover, this study provided a unique opportunity to evaluate the concept behind the "*NEAT Lamp*". In addition, I was able to conduct semi-structured interviews with the six volunteers who were testing the "*NEAT Lamp*" prototype. This phase of the design process is similar to the final step of contextual design "*mockup and test with customers (VI)*" and due to the iterative nature of this process it allows for gaining new perspectives on the

context and therefore is again "*contextual enquiry (I)*". Accordingly, this study resulted in field notes, photos and sketches akin to "*work models (II)*"

6. The observations from the second observational ethnographic study sparked ideas about how to develop the concept embedded in the first prototype further. During several meetings among the team members, particularly involving the designer, we discussed how to develop the concept in order to influence the way local movement and mobility in offices is shaped. Like the second phase, this step could be mapped to "*work redesign (IV)*"

7. This further development of the concept resulted in the design of the second prototype known as the "*Talking Tree*". Once more this prototype was not tested on paper nor were low-fi prototypes produced.

8. This second prototype was tested in a two-month pilot study in the lunchroom of the department of Informatics, Umeå University. Throughout this pilot study, colleagues made a range of suggestions. Furthermore, we asked them if such a design and its concept might be suitable for office workers to increase their physical activity and break their sedentary habits. This study was similar to the step "*user environment design (V)*" and we were keen to investigate the pros and cons of "*Talking Tree*" in an office setting.

Having provided an overview of the research process and associated methodological practices, I now present more details of the latter, starting with a description of how each one has been applied in HCI and how each applies to my research process.

The Ethnographic Study: Becoming Familiar with the Setting

Ethnography is a well-established method in social science and anthropology. It is the systematic comparative study of societies and cultures, based on detailed empirical research in concrete social contexts (Atkinson & Hammersley, 1994; Hammersley & Atkinson, 2007). Although as a discipline originally it was used for investigating non-western social settings, gradually researchers started to use this method in all societies from high-tech companies to rural villages in developing regions (Gunn, Otto, & Smith, 2013). From the twentieth century, participant observation became the dominant method of field studies (Gunn et al., 2013). At the core of ethnography is the description of culture, practices, and norms of everyday behaviors, achieved by the researchers immersing themselves in the social setting and acquiring comprehensive and detailed information (Atkinson & Hammersley, 1994). Thus, a considerable amount of time must be spent in the social setting and with the people. Ethnography has a long-standing research interest in processes of social and cultural change, human creativity and innovation (Hammersley & Atkinson, 2007). The major relationship between design and anthropology started during the 1970s when designers became aware of the value of ethnographic data and methodologies, in particular for understanding the needs and experiences of users and the contexts in which products and computer systems were used (Gunn et al., 2013). Moreover, there were genuine affinities between design and ethnography in the process of inquiry and discovery. Ethnographic studies within the field of design have been conducted to investigate use and user requirements, experience and perceptions, in relation to the object, environment, system or service (Clarke, 2011). Ethnographic studies in HCI have become a well-established method, practiced under different labels such as design anthropology or design ethnography (Barab, Thomas, Dodge, Squire, & Newell, 2004; Clarke, 2011; Gunn et al., 2013), or visual and sensory ethnography (Pink, 2009, 2013) which deals with photographs, videos and other sources of sensory data.

Ethnographic Studies – From the Humanities to CSCW

The definition of the word ethnography has been a matter of controversy (Atkinson & Hammersley, 1994), but nevertheless the subject has been widely applied within the social sciences. According to Atkinson and Hammersley

(1994), however, ethnography is a form of qualitative research that has the number of the following features:

- A strong emphasis on exploring the nature of particular social phenomena, rather than setting out a hypothesis about them

- A tendency to work primarily with unstructured data, that is, data that have not been coded at the point of data collection in terms of a closed set of analytical categories

- Investigation of a small number of cases, perhaps just one

- Analysis of data that involves explicit interpretation of the meaning and function of human actions, the product of which mainly takes the form of verbal descriptions and explanations (Atkinson & Hammersley, 1994)

Modern forms of ethnographic fieldwork were developed after a major shift by social and cultural anthropologists in the nineteenth and early twentieth centuries (Atkinson & Hammersley, 1994). Both HCI and CSCW have benefited from ethnographic studies, where they represent a common approach (L. J. Bannon & Schmidt, 1989; Barab et al., 2004; Blomberg & Karasti, 2013; Dourish, 2006; Dourish & Bell, 2011; Hughes, Randall, & Shapiro, 1992; Schmidt, 2000). The adaptation of ethnography to HCI can be associated with two trends: CSCW and participatory design (Dourish & Bell, 2011). For participatory design, ethnography has been used as a tool rather than being intellectually motivated. One of the early attempts at using ethnography and anthropology methods to understand users was by Lucy Suchman (1987). Subsequently, there has been a wide range of ethnographic studies conducted in workplaces with a specific focus on collaboration or efficiency (see, for example, (Blomberg & Karasti, 2013; Suchman, 1987; Wiberg, 2001). In the last two decades of the twentieth century, with the introduction of information and communication technologies, the concept of mobility began to expand and transform (Kakihara & Sørensen, 2001) and some ethnographic studies focused on the concept of mobility within office spaces (Bellotti & Bly, 1996; Luff & Heath, 1998). Based on these studies, mobility was considered essential for the use of shared resources and communication in workplaces (Bellotti & Bly, 1996). However, these studies only investigated local movement and mobility in relation to collaboration and cooperation in workplaces and had no interest in "*Moving Bodies*" as a separate

entity (Moradi & Wiberg, 2016b). A definition of the "*Moving Bodies*" is provided in paper II.

On Conducting Ethnographic Studies in the InPhAct Project

Ethnography is a well-established method in HCI; the main objective for using such studies for the work described herein was to understand local movement and mobility patterns in modern office environments. Note that I refer to my ethnographic studies as "*observational*"; this is because I lack the background to undertake pure ethnographic studies.

Due to privacy issues, technological surveillance systems such as video cameras or sensors were not used during the ethnographic studies. Therefore, the whole data collection process was limited to my presence in the settings and the notes and sketches that I created (see Figure 3.2).

Figure 3.2. A close shoot showing how the author conducted ethnographic studies and created sketches

During the InPhAct project, two intensive observational ethnographic studies at "*Housing Co.*" and "*Heath Co.*" were conducted, lasting for a total of nearly six months. In these two field studies, considerable amounts of data were gathered systematically in the form of sketches (see Figures 3.4, Figure 3.5 & Appendix I), field notes, and photographs and through informal and semi-structured interviews (see Appendix II). This systematic method of data collection can be loosely divided into three main steps. Contextual design seeks inspiration for design everywhere in the setting (Wixon et al., 1990). Therefore, the basic challenge when conducting ethnographic studies in common architectural spaces such as office settings is to observe the familiar from an outsider's point of view. Moreover, it is necessary to examine the extraordinary events that happen daily

in the workspaces. They are no specific formulaic methods for conducting observational studies; instead, the approach should be personalized and focused on discovering hidden patterns and rules (Clarke, 2011; Gunn et al., 2013). In this regard, I highlight three steps that had a significant effect on the data collection process and ultimately helped me to find ways to increase my understanding of local movement and mobility in office spaces. These steps are *Improvisation*, *Reflection* and *Envisioning*.

Improvisation in data collection refers to certain moments of creativity that happen during fieldwork that help the researcher to collect data. In the case of this work, improvisation happened in the form of sketching daily pathways taken by office workers. Gradually these sketches were elaborated and I enriched them by adding details with the use of color-coding (see Figures 3.4, Figure 3.5 & Appendix I).

The next step, *Reflection*, emphasizes the importance of the constant ruminations of the researcher during ethnographic studies in the actual setting. In general being reflective is an important factor in being a practitioner and a designer (Schön, 1983). It is worth mentioning that conducting field studies is a delicate task that should be carefully considered. It is crucial to be reflective not only about the quality of the data gathered but also about the behaviors and attitudes adopted by the observer. One example was the introduction of the first prototype, the "*NEAT Lamp*" to the setting during the "*Health Co.*" study. The second study was not purely ethnographic: we were conducting ethnography and testing the "*NEAT Lamp*" prototype simultaneously. One of the challenges of such studies is preserving the balance between being simultaneously an observer (conducting ethnography) and an intruder (prototyping). In the contextual design steps described earlier, user testing with prototypes is important. In the case of the research for this thesis, I decided to use an ethnographic study whilst also examining the setting with the "*NEAT Lamp*" prototype in place.

Figure 3.3. The office with the glass window

Therefore, conducting ethnography and prototyping at the same time helped me to test and further develop concepts. Returning to the example, one of the challenges in the "*Health Co.*" study was placing the "*NEAT Lamp*" as a piece of new technology. Furthermore, in conducting my ethnographic studies there was always a challenge about where I should locate myself within the setting. As I

Figure 3.4. The researcher's location became a node, interacting with the pathways around it

was openly keen on documenting the physical movements of office workers in the setting, individuals tended to be cautious about deliberately wandering through the space. This challenge was highlighted even more during the second observational study because it involved both ethnography and prototyping. By *Reflecting* on this challenge, I spotted the perfect office, which was empty at the time, to relocate to. This office had a view to the left and a glass window to the right, which allowed me to conduct my observations (see Figure 3.3). However, this relocation resulted in an interesting phenomenon emerging in the data. Figure 3.4 is an example of data collected on the eighth day of the study. The office that I was relocated to was identified by the number 21. Based on this data, it is clear that my location was turning to a functional node within the workspace. New paths are appeared in the direction of office 21, and now I was perceived as a colleague in the setting rather than an observer conducting a study. One could argue that breaking the boundaries to this extent between the ethnographer and the setting would damage the validity of the ethnographic study. However, this experience demonstrates the importance of the natural flow of movement among office workers.

Envisioning is the ability to see the setting beyond its physical appearance. In fact, it is akin to the second step of contextual design "*work modeling*". I gained

Figure 3.5. Envisioning the setting for data collection

this ability by spending considerable time in the setting and becoming familiar with it. The first example of *envisioning* occurred in the "*Housing Co.*" study. After being in the setting for a number of days, it became clear that there was a social network within the physical landscape. Therefore, new ways of sketching the movement and mobility of the office workers were possible (see Figure 3.5). These new sketches highlighted local movements based on personal and social relationships between office workers instead of physical representation of local mobility. Such sketches added value to the other sketches that were based on physical representations of movement and mobility in the office.

Concept Development: Grounding the Design in the Setting

In recent decades, with the growth in the design and use of computing, many researchers and practitioners have turned to ethnography (Dourish, 2006). Despite this wide use of ethnography in HCI and design, there is still confusion regarding the role of this method and the contribution that it can make (Dourish, 2006). Commonly ethnography is perceived as an approach for investigating the

field in order to identify requirements for systems development (R. J. Anderson, 1994). Others have explored the issues of ethnography and design as a reflection of the social–technical divide (Ackerman, 2000), encounters between technologists and customers (Suchman, 2002), or have investigated different models of ethnographic analysis (Button, 2000).

However, taking this approach fails to capture the true value of this method (Dourish, 2006). The aim of observational ethnographic studies in the current research process was to identify requirements for design with the aim of "*contextual inquiry*". In fact, observational ethnography was used to understand, organize and interpret the local movement and mobility of office workers in the workplace. Conducting such observational ethnographic studies led to concept development and redefining concepts, as a way of "*redesigning work*". By pointing out the commonalities within the data gathered in the observational ethnographic studies, and with the help of the team, we were able to create a foundation upon which to base our concepts.

Concept–Driven Design & Strong Concepts

Generating concepts that can function as explicit ideas underlying the design of prototypes is a common approach within the HCI field. While investigating ways to develop concepts, I encountered two approaches: concept-driven design presented by Stolterman and Wiberg (2010) and strong concepts introduced by Höök and Löwgren (2012). There are many other papers and studies concerning the role of concept development but in this thesis I focus on these two approaches, which were the ones most influential to me.

In a series of papers, Stolterman and Wiberg aimed to analyze and conceptualize interactive systems (Stolterman & Wiberg, 2010, 2015; Wiberg & Stolterman, 2014). Developing concepts and prototyping are common practices in HCI and interaction
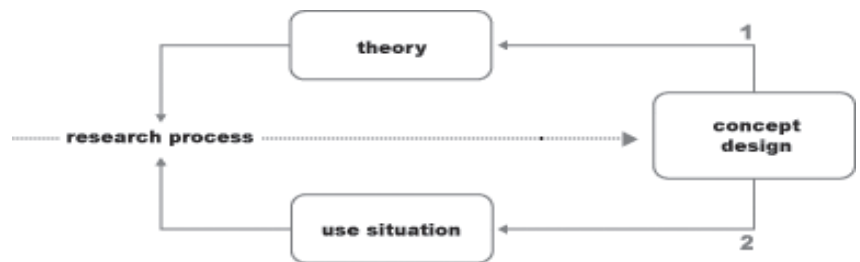

Figure 3.6 Relationship between the research process, theory and use in concept-driven design (Stolterman & Wiberg, 2010)

design (Fallman, 2003; Wiberg, 2014), but there is still a lack of documented methods related to taking design ideas and concepts forward and generating knowledge through design (Wiberg & Stolterman, 2014). So, how do we conceptualize existing designs and how do we generate new knowledge that can contribute to the existing body of knowledge? Although these questions have been the focus of research in recent years (Höök & Löwgren, 2012; Stolterman & Wiberg, 2010) there are still few detailed methodological suggestions (Wiberg & Stolterman, 2014). The design process that I used is intended to contribute to the discussion by providing methodological details of the research process applied.

In concept-driven design research (Stolterman & Wiberg, 2010), the focus is on knowledge production in the form of theoretical or conceptual development. It involves an exploratory investigation of established theories with the overall aim of improving and widening the range of theory and knowledge. Overall in this type of research, there is a deliberate intention to theorize about the nature of interaction (see Figure 3.6).

> "*The concept of the design becomes a carrier of knowledge but also establishes a conceptual framework and challenge for future design work* "(Stolterman & Wiberg, 2010).

The key of a conceptual design is to manifest all the combined knowledge that will influence the design so that "*the knowledge is embodied in the artifact*" (Stolterman & Wiberg, 2010). In a similar approach, Höök and Löwgren (2012) introduced the notion of "*Strong Concept*", which is generative and also carries the core idea of design. They claim that strong concepts are design elements, but at the same time are a part of the designed artifact. They address use practice and behavior over time. These concepts are more specific than theories, illustrating the idea of abstraction (Höök & Löwgren, 2012). A concrete artifact is an artifact that is used in the situation that it is designed for. However it could have levels of abstractness, which could come into use in particular situations for the sake of productivity-oriented application (Höök & Löwgren, 2012).

Applying conceptual thinking provided me with the necessary knowledge for "*redesigning work*". However, "*redesigning work*" in this thesis focuses on how to design for active bodies in workplaces rather than redesigning the work process. Thus, conducting observational ethnographic studies prior to developing the concept empowered me with the situated knowledge of the

setting. Such an expansion in knowledge leads to a stronger theoretical and empirical understanding enhancing the development of concepts. A good theory is not one that is only capable of describing the present, but one that enables us to predict the future (Wiberg, 2014). Herein, I argue that promoting such a contextual design process, including observational ethnographic studies, concept development and prototyping could provide a solid grounding for such theoretical advancements. In fact, concept development is a crucial stage in this research process. Concept development is a bridging activity between observational ethnography and the design process.

The Development of the "NEAT Lamp" Concept

After the "*Housing Co.*" study was conducted, the data was coded with more than 1200 open codes and common themes emerged. The "*NEAT Lamp*" concept was developed as an outcome of considering these data in a brainstorming session involving researchers from the fields of public health and design (see the 2nd

phase in Figure 3.1). This concept was inspired by studies conducted in public health in relation to increasing Non-Exercise Activity Thermogenesis (NEAT) (Levine et al., 1999). The "*NEAT Lamp*" was the first prototype that was designed around this concept (see Figure 3.7). This simple USB-connected system provides an indication to the office worker that they have been sitting for more than 25 minutes. There is evidence for the beneficial medical effects of avoiding sedentary behavior (D. W. Dunstan et al., 2012; Healy et al., 2008) and so the "*NEAT Lamp*" prototype is designed around this idea. This prototype was tested in an intensive study for more than two and half months during the second observational ethnographic study.

Initially the idea of "*NEAT Lamp*" concept was raised during the first observational study. With increasing time spent in offices, the possibility of using objects within the setting to encourage local movement and mobility became increasingly clear. In an office-type setting, both human and non-human actors interact all the time. Therefore, to understand the movement of office workers the focus should not be limited to the workers, but rather to a general framework that fosters such movements in the setting. Intensive empirical studies in the research process, along with concept development and prototyping provide a grounded knowledge for

Figure 3.7. NEAT Lamp, the first prototype embodying the "*NEAT Lamp*" concept

Figure 3.8. Objects incorporating the "*NEAT Lamp*" concept

"*consolidation*" leading to understanding local movement and mobility in offices. Gradually, after conducting the second observational ethnographic study, this picture became more clear. Influenced by public health studies that translated similar insights into a model describing sedentary behavior (Owen et al., 2011), we took the same approach. As a result, the knowledge gained is illustrated in the form of a framework describing local movement and mobility in workspaces. The properties of objects can be used as an agency to reshape local movement patterns, as realized in the form of the "*NEAT Lamp*" concept. This concept refers to an agency embedded in the object that fosters non-exercise activity while interacting with the object. A common example in every office is the printer, which is the focus of movement. Figure 3.8 shows examples of such objects with inherent "*NEAT*" properties. Whilst the objects shown in Figure 3.8 embody the "NEAT Lamp" concept without purpose or intention, the "*NEAT Lamp*" prototype and the "*Talking Tree*" represent deliberate designs intended to represent the concept.

Prototyping: Making the Concepts Concrete

Designing and evaluating prototypes is a common practice in HCI research. While HCI has been very ambitious developing methods for generating new ideas and designs, we have neglected to trace these designs and ideas (Wiberg & Stolterman, 2014). Moreover, when it comes to the anatomy of prototypes, we suffer from a lack of knowledge about their nature (Lim, Stolterman, & Tenenberg, 2008). Prototypes are a specific kind of object used in the design process. In relation to this thesis the "*NEAT Lamp*" and "*Talking Tree*" were the two prototypes utilized in the process of research through design. Like the research through design approach, we considered that our design artifacts (in this case the two prototypes) have the potential to transform the world from the current state to a better future state (Zimmerman, Forlizzi, & Evenson, 2007). During the first wave of HCI research, design mostly targeted usability engineering. Over time, trained designers drew on different aspects of design such as color, typography and visual hierarchy, leaving traces of "*creative design*" (Löwgren, 1995). Later, Fallman classified HCI as a design-oriented field

of study were researchers are engaged in designing and making prototypes to demonstrate a research contribution (Fallman, 2003). In this section, I focus on prototypes and evaluate them in the actual setting (see 3rd -8th phases in Figure 3.1).

Prototyping: Moving from the "NEAT Lamp" Concept to the "NEAT Lamp" Prototype

Concept driven design is an approach developed to combine empirically-driven methods with conceptual elaborations to explore new conceptual ideas in design (Stolterman & Wiberg, 2010). One of the best ways of manifesting such an intention is through prototyping. Prototyping and user involvement are at the core of contextual designing, which is the foundation of my research process. Prototypes are one of the best means for researchers to learn, discover, generate and refine concepts. In this regard, our original "*NEAT Lamp*" concept was manifested in the form of a simple sensory lamp. This simple prototype went through two iterations before the final design (see Figure 3.9). Furthermore, one of the early versions of the lamp was tested in the department of Informatics by one of the administrators during a three-week a pilot study (4th phase). Eight final version prototype lamps (see Figure 3.7) were made and six volunteers evaluated one each during the second observational ethnographic study.
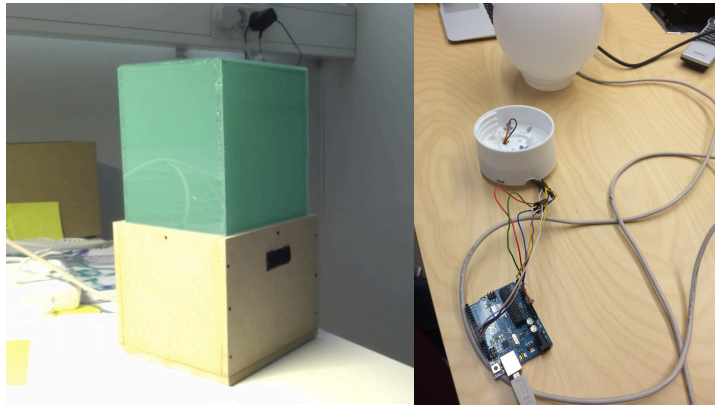
Figure 3.9. Different iterations of the "*NEAT Lamp*" prototype

The "*NEAT Lamp*" prototype is a simple, subtle prototype designed as a notification system for office workers to highlight prolonged stationary behavior. Other notification systems have been developed and utilized in the public health sector to encourage office workers to take short breaks (Healy et al., 2008; Taylor et al., 2013). The "*NEAT Lamp*" concept has a very similar motive behind it, however the difference lies in the physicality of the design. The main idea of the "*NEAT Lamp*" prototype is to avoid the focus on screens in workspace design and to present information in the form of an ambient display. Ambient displays used to provoke behavior change have long been used in different contexts, as

described in Part II (Consolvo, Roessler, & Shelton, 2004; Forlizzi et al., 2007; Rodgers & Bartram, 2011). However, unlike the majority of the prototypes that are tested in short studies, in this thesis the "*NEAT Lamp*" was evaluated in a prolonged observational ethnographic study lasting more than two and a half months.

Evaluating or Prototyping in the "Health Co." Study?

The second observational ethnographic study was designed to evaluate the "*NEAT Lamp*" prototype (see 5th phase in Figure 3.1). Details of how this second study was conducted are discussed in paper III. Here, I address the issues and challenges encountered while conducting the "*Health Co.*" study.

Conducting observational ethnographic studies while examining the setting in relation to our prototype required careful consideration of all aspects of the study, particularly because this study was conducted in a working office. In general, observing office workers during work hours in their offices is challenging, requiring the observer to maintain some distance and avoid causing any disturbance. This challenge becomes more complicated when ethnography and prototyping are combined. On one hand, ethnography is mainly based on the idea of being a "*fly on the wall*", trying to avoid any influence or disturbance in the setting. On the other hand, prototyping involves adding a new element and thus disturbing the setting. As a researcher, keeping a balance with respect to deciding how to interrupt the setting and when to step back is a constant issue. During this second study, such choices were based on the experience gained during the "*Housing Co.*" study, along with my intuition and understanding of the setting. For example, if there was a technical error with one of the "*NEAT Lamps*", I maintained my role as the observer until the participant interacting with the prototype specifically asked for my help in adjusting the lamp. The fact that one of the participants was so ambivalent about our "*NEAT Lamp*" prototype was in itself interesting, and I preferred to observe it as it was happening. Other participants, however, were much more involved with the prototypes and constantly asked for help if there was a malfunction.

The challenges of prototyping in the actual setting were not limited to combining the method with an ethnographic study. Prototyping in a real situation is a dilemma, posing the problem of whether there is really room for such an approach. If there is limited opportunity to play around with the prototype, then

it might be that we are just evaluating the design rather than conducting prototyping. In particular, in the context of this thesis, the participants were full-time office workers, and so I was very cautious about my level of engagement with them in order to avoid disturbance. However, despite the challenges of combining these two methods, I did identify hidden features of the prototype that would have been missed in a shorter, less detailed study.

Concepts Redefined: From NEAT Lamp to Talking Tree

Conducting observational ethnographic studies while examining the setting with the prototype in it provides us with a deeper understanding of both the context and design. This is very valuable when we are reevaluating the concept behind the design. Indeed, while observing the prototype we are also examining the concept behind the design. In fact design is considered as a dialectic between existing and new directions (Wixon et al., 1990).

During our "*Health Co.*" study, while prototyping the "*NEAT Lamps*", we soon observed a hidden feature within our design that we had totally overlooked. The "*NEAT Lamp*" design was intended to provide a simple and subtle notification system to remind the office worker of their prolonged immobility. However, when the "*NEAT Lamps*" were used in the "*Health Co.*" study, it became evident that the light cast by the lamp on

Figure 3.10. The light cast by the "NEAT Lamp" on the ceiling

the ceiling made a statement that was visible all over the office (see Figure 3.10). Therefore, an interaction that was designed to be only between the office worker and the lamp was now visible for everyone else to see. Suddenly a social factor was added to the "*NEAT Lamp*" concept. In papers III, IV & V we discuss this hidden feature of the prototype extensively.

Figure 3.11. Talking Tree

Figure 3.12. The talking tree from a Persian manuscript of the Shahnameh

The result of this study was the design of our second prototype, the "*Talking Tree*" (Figure 3.11). This prototype was designed on the basis of the same "*NEAT Lamp*" concept, with a social feature embedded within it. The "*Talking Tree*" was inspired by the mythical Persian story told in epic poem of "Shahnameh" – the story of kings. Trees are frequently a symbol of wisdom in literature and stories; for example, when Alexander the Great reached the end of the world, he encountered a tree with two trunks intertwined, foretelling his future (Ferdowsi, 2016). The "*Talking Tree*" has been illustrated in various manuscripts, like the one presented in figure 3.12.

This prototype reflects collective mobility in the surrounding space rather than focusing on an individual's activity level. The ambient display takes the form of a plant. With the use of several sensors located in different corners of the room the "*Talking Tree*" can detect movements within the space. The level of movement is quantified and when a threshold level is reached, the color of the plant's leaves changes. The tree appears to be alive and green when there is local movement and thus the mobility of the office workers nurtures the plant. "*Talking Tree*" is a concrete example of how simple concepts develop during the process of prototyping and observing.

Part IV:

Presentation of the Findings

Introduction

This thesis is the outcome of four years of work, resulting in the five papers listed in Part I. Three of these have already been published, whilst two are currently under review by international journals.

Figure 4.1 shows the detailed, color-coded timeline of the work involved. The first row represents the writing process and the second row the research process, running from October 2012 until December 2016. In the diagram, red indicates two short papers that are not part of this thesis but had an influential role in shaping my ideas when writing the five main papers (indicated in green). Purple indicates the phases. The first quantitative study is highlighted in orange: it has not been mentioned in the research process but was briefly mentioned earlier in the text.

The writing and design processes provided me with opportunities to engage in discussion with other academics at conferences and also via feedback received from reviewers and co-authors. Each one the five papers in the thesis contributes to the knowledge gathered from the design process that ultimately aided me in answering my research question. This section includes a summary of each paper their individual contributions to the complete thesis.

Summary of Paper I

Moradi, F., & Wiberg, M. (2013). Redesigning work–from sedentariness to activeness. *Procedia Technology*, *9*, 1005-1015.

Paper I

Having in mind the core values of social care and healthcare Information Systems, this first paper argues the importance of investigating the setting before designing such systems. Given the many hours that adults spend sitting down during their daily work, many designers have been encouraged to develop systems to promote an active working life, although few have investigated these environments before undertaking their design work. This paper was our first attempt to focus on the history of workplace design over the past 70 years. We argue that technological developments over the decades have resulted in sedentary working.

Short Paper 1: Wiberg, M., & Moradi, F. (2013). Information and Engagement in Personal Informatics Systems Design. In *The Power of Information Conference, Brussels 20-23 Jan.*

Short Paper 2: Moradi, F., & Wiberg, M. (2014). Moving Bodies: Designing Spaces with the Body as an Interactive Architectural Element, In the Workshop MovingBodies: Interactive Materials in Architectural Space, CHI2014.
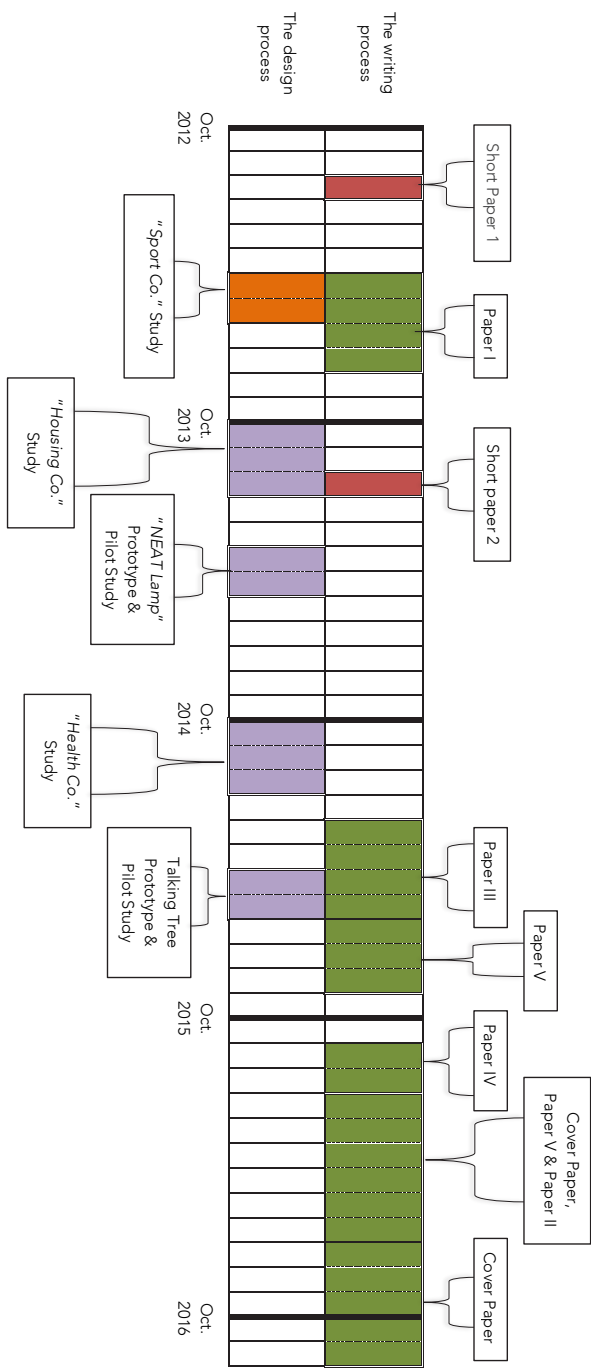
Figure 4.1. The timeline of the thesis activities, from October 2012 to October 2016.

The paper starts by briefly mentioning the hazards of prolonged sitting and then examines the history of sedentariness in workplaces. As being seated is considered the core of today's offices, many individuals compensate for their sedentary life in one domain by being active in another. International organizations such as the World Health Organization and the American Heart Association have made recommendations to reduce the risks associated with prolonged sitting. To gain a better understanding of how people compensate for their inactive life, we conducted a quantitative analysis using data gathered from one of the biggest sport clubs in northern Europe, referred to as "*Sport Co.*" in this thesis. The results of this empirical study show that the majority of people fail to achieve the recommended level of exercise. Although in recent years digital technologies, such as Personal Informatics, have been designed for self-quantification to encourage people to be more active in daily life, we argue that there is a need to consider activities at work and within office spaces in order to redesign work.

Given that the history of workplace design has brought us to the point where we are accustomed to prolonged sitting, and the fact that this inactive lifestyle has gradually imposed itself on us, this papers ends by discussing ways to move forward. This paper contributes to the current development in the field by offering an alternative design paradigm and suggests that concept-driven design is one possible way forward.

My Contribution: As the main author of this paper I was inspired by the preliminary literature review undertaken at the beginning of my PhD research. I was responsible for collecting the data for the empirical study and conducting the quantitative study. I also led the process of writing; however, as a team effort, the guidance of Mikael Wiberg had a noticeable influence on the final outcome.

Summary of Paper II

Moradi, F. (2016). Breaking Free: The Paradox of Bodies in Workspaces. Currently under review (1st round) by an international journal.

Paper II

The second paper originated from the main idea of the first paper of further examining the history of workplaces from factory floors to modern offices. This paper starts by describing the relationship between the

history of work design and the history of bodies at work. The paper highlights the importance of bodies as sources of effort, knowledge and skill in workplaces. This key role of bodies in workplaces has resulted in changes with respect to work that have directly affected human bodies. To gain a deeper understanding of these changes, this paper starts by describing three modes of bodies in workplaces: the know-how body, the thinking body and the stationary body, as originally categorized by Zuboff (1988).

In order to speculate about redesigning work as described in the first paper, one should not be restricted by the historical path of work design. We should immerse ourselves in the contextual details of everyday working life in an office setting. Therefore, in this paper, I reported on the first observational ethnographic study, the "*Housing Co.*" study. The aim of this observational ethnographic study was to understand local movement and mobility among office workers. After observing the office setting for nearly three months and collecting qualitative data, I was able to see common patterns in the daily movements within the office space. Gradually the knowledge that I gained guided me to categorize the five main agencies that are influential in shaping the patterns of local movement and mobility. These five agencies are *temporal appropriation*, *spatial possibility*, *social relation*, *organization policies and norms*, *individual characteristics* and finally *the power inherited in artifacts that forces office workers to move*.

After describing these agencies, the paper goes on to discuss the importance of breaking away from the current mentality behind designing work. In particular, the way bodies have been treated is a paradox: they are very important for completing tasks but are seldom in focus for their own good. Finally, the paper suggests a role for HCI and Interaction design in redesigning work by creating new modes of interaction with computer systems in workplaces: transforming the thinking body to the engaging body, leaving behind screen-based interfaces and moving towards ambient and tangible interaction in today's workspaces.

My Contribution: This paper was single authored and explores the idea of redesigning work. Although the idea behind this paper was developed during the "*Housing Co.*" study it was written in the summer of 2016. As the only author of this paper I was responsible for all aspects of it.

Summary of Paper III

Paper III   The third paper of this collection is a book chapter discussing the role of architecture and interaction design. In this paper we were particularly interested in bodily movements in workspaces as a good example of an architectural space that has been widely shaped by Information Technology. The role of historical developments and particularly the technological advances in shaping the workplaces of today were extensively described in the first two papers. This paper starts by introducing the concept of "*Moving Bodies*". "*Moving Bodies*" as interactive elements in workspaces are a way to develop a guiding concept for interaction design in architectural spaces. This concept was influenced by theories concerning bodily movements. To define this concept, we start by discussing the relationship between modernity and mobility and gradually move on to describing how modernity has affected "*Moving Bodies*" at the individual level. The first section of this chapter ends by discussing the role of "*Moving Bodies*" in workspaces.

The second section discusses the two observational ethnographic studies that I conducted during the thesis work. Unlike the "*Housing Co.*" study, the process of the second observational ethnographic study, the "*Health Co.*" study is described in detail. After discussing the approach adopted when conducting these studies, the paper moves on to describe the implementation and data collection. In this section we emphasize the role of objects in workplaces that encourage office workers to move about, creating "*Moving Bodies*" that function as interactive elements in the office space.

After describing the concept and the design of the "*NEAT Lamp*", the study plan and the object of the "*Health Co.*" study is discussed. Unlike the "*Housing Co.*" study, this study had a specific plan and in addition to the qualitative data gathered through the observational ethnographic study and interviews, quantitative data was also gathered using Fitbits as step counters (this is described in detail in the chapter). Before outlining the results of the study, a description on the actual setting in which the "*Health Co.*" study was conducted

is provided. The results of the observational notes, interviews and quantitative data are then presented. The chapter ends by returning to the concept of "*Moving Bodies*" and how we have benefited from exploring interaction design and architectural spaces. Finally, we discuss the role of this concept in shaping our further studies.

My Contribution: I was the main author, with the guidance of Mikael Wiberg. This publication was originally accepted in the form of a workshop paper for CHI 2014. Subsequently, the paper was further developed, extended and submitted in the form of a chapter to the book "*Architecture and Interaction*". I led the process of writing and I took the main role in writing and conducting the studies. In this chapter, I tried to move on from the historical perspective of bodies in workplaces and focused on describing the two studies that I conducted and how these studies can influence my future studies.

Summary of Paper IV

Moradi, F., & Wiberg, M. (2016, July). Creating a Sense of Unity: From Quantified Self to Qualitative Space. In *International Conference on Universal Access in Human–Computer Interaction* (pp. 371-381). Springer.

Paper IV   This fourth paper of this collection follows up on the previous publication by exploring the role of architectural spaces in the design of Personal Informatics (PI). This paper focuses on the design of PI systems with respect to office workers' physical movements in architectural spaces. The paper starts by providing some background about Personal Informatics (PI) and Quantified Self (QS) and goes on to describe our research approach in terms of the observational ethnographic studies and the design of the "*NEAT Lamp*".

Subsequently, the paper mainly focuses on the hidden feature of the "NEAT Lamp" prototype that was noticed in the "*Health Co.*" study, namely the reflection of the light of the "*NEAT Lamp*" on the ceiling. The open landscape of the workspace that this study was conducted in allowed all the other office workers to see how each individual was interacting with their lamp (already noted in paper III). This observation provided an opportunity for us to discuss ways of moving beyond the current designs of PI systems. We became interested in designing systems that shape the architectural space through our experience

of being. In this paper we go on to discuss the phenomenological view of building and architectural thinking. In the end, we hope that by introducing this prototype we can open up discussions exploring new ways of designing PI systems. In addition, we highlight the importance of employing architectural thinking that considers all the elements of space as architectural forms, including moving bodies. By focusing on the intersection between interaction design and architecture space in designing PI systems, we can move beyond the traditional first-person/user-centered perspective. In this way by thinking of bodily movement and space together we can create a sense of unity with respect to qualitative space.

My Contribution: This paper was an attempt to contextualize the ideas of architectural thinking and interaction design within the design of PI systems. As the main author of this paper I wanted to investigate the ideas presented in paper III with respect to the design of PI systems. I led the writing process and was responsible for the majority of the text. I was in charge of conducting the studies, and this paper was completed with direction and feedback from Mikael Wiberg.

Summary of Paper V

Moradi, F., Deshpande, P., Wahlström, V., Olsson, T., & Wiberg, M. (2016). A NEAT Solution: Where Interaction Design and Public Health Meet. Currently under review (1st round) at an international journal.

Paper V This final paper provides an overview of the research process and the cross disciplinary experience of the Increasing Physical Activity (InPhAct) project. It starts by describing the problems associated with prolonged sitting and highlights the need to increase office workers' physical activity and break the habit of prolonged sitting in offices. The paper highlights the importance of conducting such studies in cross disciplinary teams and continues by briefly describing the InPhAct project and related work in this area of study from both the Public Health and informatics perspective.

We then describe the design rationale, including the empirical and design work. As well as elaborating on of the "*Housing Co.*" and "*Health Co.*" studies and discussing the "*NEAT Lamp*", the second prototype, the "*Talking Tree*", is also

introduced. In fact, this paper presents all the phases of the design process presented in Figure 3.1. This design process provided us with robust data describing local movement and mobility in offices. As discussed in paper II, the movements of office workers form a pattern that can be altered by several agencies. Inspired by the field of Public Health and Clinical Medicine, the framework was gradually developed further through the design process and it is detailed in this paper.

However, the contribution of this paper was not limited to this conceptual framework. The paper also discusses the evolution of InPhAct from the perspective of a cross-disciplinary research project. During the project our collaboration developed in three phases. The first ran from the beginning of the research process to the design of the "*NEAT Lamp*" (from the 1st -3rd phase, Figure 3.1). In this phase of research our collaboration was close to the standard definition of multi-disciplinary research. The next phase of our collaboration was between the time when the "*NEAT Lamp*" was evaluated in the "*Health Co.*" study to the design of the "*Talking Tree*" (4th -8th phase, Figure 3.1). In this phase our collaboration was moving towards an interdisciplinary research project. But in fact, it was in the final months of the research project that the nature of our collaboration transformed into a transdisciplinary research project. In this stage, we crossed our disciplinary borders in developing and discussing our conceptual framework and coauthoring this paper. The paper ends by summarizing the research process of the InPhAct project.

My Contribution: As the main author, I was responsible for the collaboration between all the team members involved in writing this paper. Apart from conducting the studies, I wrote the majority of the text of this paper. In addition, I initiated the development of the conceptual framework. However, without the help of all the team members this conceptual framework would not have been possible. These close collaborations when working on the framework and the paper provided the idea of describing the nature of our collaboration as a cross-disciplinary team, an idea developed and refined by the other members of the team.

Part V:

Reflection & Concluding Remarks

Introduction

The design and development of Personal Informatics (PI) and Quantified Self (QS) systems to break habits and encourage behavior change is a fairly new aspect of research in the field of HCI (Li et al., 2010; Swan, 2012). Despite the different domains that PI systems have been applied to, a growing number have been designed to break sedentary habits and increase physical activity. These body and movement-based systems have been designed in different forms, from simple step counters to ambient displays and smart watches. The majority of these designs encourage users to increase their physical activity during leisure time while the stationary lifestyle has predominated in all aspects of our daily lives. There has been a clear message from Public Health and Clinical Medicine researchers, however, emphasizing the importance of breaking the habit of prolonged sitting among office workers and increasing physical activity in workplaces. In this regard the research described in this thesis aimed to investigate ways to design for active bodies in workplaces. Being influenced by the steps and principles of contextual design, a design process specifically developed based on three methodological approaches: observational ethnographic study, concept development and prototyping. As a result, two extensive observational ethnographic studies were conducted, a design concept was developed and modified and two prototypes were designed and evaluated. This design process resulted in the production of contextual knowledge about bodily movement in workplaces that has been presented in five peer-reviewed papers (see Part IV).

In this section, I present my reflections on this cross-disciplinary design process. This thesis was conducted as part of a cross-disciplinary research project, Increasing Physical Activity (InPhAct), involving researchers from Public Health and Clinical Medicine, Umeå Institute of Design and Informatics all investigating ways of breaking sedentary behavior in offices and increasing physical activities among office workers. In paper V we provided a detailed description of the nature of our collaboration

Figure 5.1. The cycle of the collaboration in the InPhAct project with the target of study in the middle

in the different phases of the research. However, the point of conducting cross-disciplinary research is to benefit from the knowledge of every collaborator. Figure 5.1 illustrates how my research process benefited from the studies and knowledge produced by colleagues in the Public Health and Clinical Medicine department. It also shows how the knowledge I gained in the research process (see Figure 3.1) has contributed to their research and studies. Note that as my research was conducted in close collaboration with the designer on the team, the figure mostly focuses on the collaborations between the Public Health and Clinical Medicine experts and the process of design adopted in this thesis. During the InPhAct project, I benefited from the studies conducted in Public Health, such as understanding the severity of the problems associated with prolonged sitting (Thorp et al., 2012; Van der Ploeg et al., 2012; Van Uffelen et al., 2010) and the role of increasing None Exercise Activity Thermogenesis (NEAT) (Levine, 2002, 2004) in interrupting our sedentary lifestyle. In return, my research contributed to the InPhAct project by rethinking the design of IT. In fact, this process highlights the importance of redesigning work for the sake of healthy bodies in workspaces.

Based on the knowledge gained in my research I made two main contributions. The first relates to the research question presented in the first part of this thesis. The second contribution is a discussion around the research process that was specifically tailored to my research. In this section I discuss how this process can inspire other researchers facing similar research questions. I elaborate on the idea of designing for bodily movement in offices by exploring the design space for bodies in workspaces. Discussions around this design space open up further design implications, so I go on to focus on research. My design process was tailored specifically for this thesis, providing ideas for subsequent research methods. Finally the limitations of this work along with future steps are briefly mentioned.

Reflecting on the Design Space

The history of work design is interrelated with the history of bodies in workplaces. Based on the knowledge gathered in my design process, I was able to conclude much about the form of a design space. "*Working Out Work*" examines the research question through the lens of contextual design from a Personal Informatics perspective.

How can we approach the design of work in today's offices in order to make office workers more physically active in their workspaces?

Design space can provide the opportunity to rethink the process of designing work with today's digital technology while acknowledging physical activity at work. The design space discussed in this thesis functions as a conceptual tool and so, like any other tool, it enables us to perceive some aspects of work design clearly. At the same time, this conceptual tool can prevent us from seeing other aspects of the situation and therefore it does not allow us to see the whole picture.

Reflecting on the Design Space from the viewpoint of a Conceptual Tool

The design space in this section (see Figure 5.2) is sufficient for presenting the concluding marks in relation to the research question. The figure shows that a vertical line separating the design of each task from the other tasks. These tasks are not limited to office workers and can be related to any type of work design. However, as this thesis particularly focuses on designing for office workers, I limit the examples to this context. When designing each task, two aspects are considered. The x-axis indicates how the design of the task affects productivity in executing the job. The y-axis, in contrast, indicates how the designed process effects office workers' bodies. Four points will illustrate this model (see Figure 5.2) in more detail, inspired by the knowledge I gained through my research.
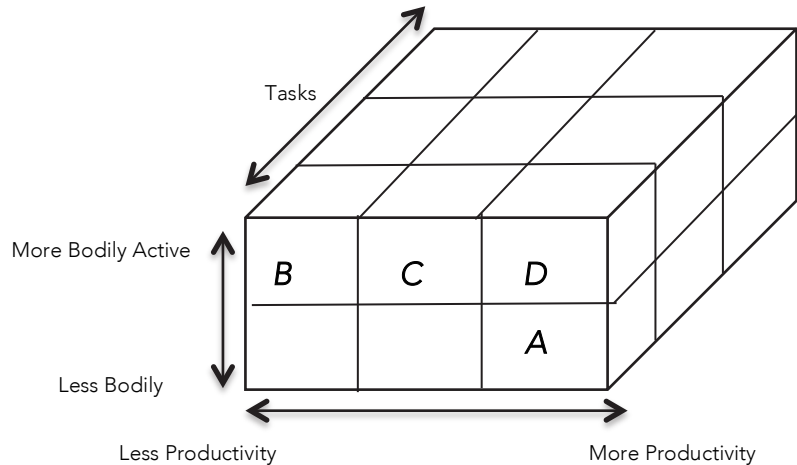
Figure 5.2. The design space of work design in relation to bodies as **a** conceptual tool

A. This point in the design space is a good example of how we have traditionally designed work. In such designs, the most important factor was to maximize productivity. There was no intention to harm the body in these designs, but neglecting the body did result in damage. One of the latest but simple examples of such a design is using a chair in workspaces. The idea of sitting to undertake office work results in higher productivity but, at the same time, prolonged sitting harms our bodies.

B. Point B, in direct contrast to point A, represents an approach to designing work in which the priority is to confer the greatest benefit to the bodies of office workers, with a simultaneous negative effect on productivity. An example of such a decision in an office would be to install fast treadmills for the office workers to use. Another example would be to encourage the workers to participate in walking games such as Pokémon during their work hours.

C. In the middle of the design space are those designs that have a neutral effect on the productivity of work but at the same time have a positive effect on physical activity. An example of these designs could be Breakaway (Jafarinaimi et al., 2005), the "*NEAT Lamp*" prototype and the "*Talking Tree*". These designs are purposefully made to provide a change in office workers bodies without interrupting the process of work.

D. The ideal point of designing work in relation to bodies would be the top right side of the design space. The further a design moves towards the top right corner, the more productive it is and the more it involves more bodily movement. An example of such a design could be found in the studies indicating the importance of mobility in increasing collaboration among the team members (Bellotti & Bly, 1996; Luff & Heath, 1998). In this case, physical movement benefited the office

workers' health and the process of executing the task, resulting in increased productivity.

Discussion & Implications for Design:

The design space indicates the complexity associated with designing work for active bodies in workplaces. When designing work, each task has its unique specifications and so a solution for one task will not necessarily apply to other tasks. The challenge for designing physically active workers is finding the most suitable point in the design space (see Figure 5.2). Designers must create a balance between maintaining the productivity of work while encouraging physical movement. My research suggests that to find this balance, we need to incorporate prototyping in the design process. Iterative prototyping and evaluation in the actual setting would help us to explore the design space in relation to the task we are designing and would allow us to discover hidden features of our prototype.

Tailoring the Research Process

Designing prototypes and evaluating them in the actual setting brings us to the methodological contribution of this research. Taking a contextual design (Beyer & Holtzblatt, 1997; Wixon et al., 1990) approach is important for fostering physical activities in workplaces. Executing a contextual design approach when conducting a project could be as simple as following the steps and principles described by Beyer and Holtzblatt (1997). However, each research and design project has its unique characteristics and circumstances. The advantage of applying contextual design thinking in a research and design projects is that it enables you to tailor your methods, skipping some steps and extending others whilst still following the main principles. "*Contextual design can be a template for designing your design process*", as Beyer and Holtzblatt (1997) describe. The concept of tailoring the research process was covered in detail in Part III of this thesis. In fact, the contribution of contextual design lies in the set of techniques it provides for gathering initial data, defining system function and providing structures that work for the customer. In this way contextual design provides a backbone for designing customer-centered processes (Beyer & Holtzblatt, 1997).

The Research Process Adopted in this Thesis

One of the main steps in conducting this work was tailoring the research process. Contextual design was selected as the backbone of this process, supported by observational ethnographic studies, concept development and prototyping. The positive effects of employing an iterative process have been widely reported when developing software and undertaking the HCI process. Similarly, in the design process adopted in this thesis the role of the iterative process was a crucial factor (see Figure 5.3). This process involved both empirical work and design work. The empirical work was conducted in the form of observational ethnographic studies and the design process was executed in the form of concept development and prototyping. In the process illustrated in Figure 5.3, there is an emphasis on evaluating the prototype in the actual setting via an observational ethnographic study. These evaluations will help to reveal hidden aspects of the prototype, which can lead to redefinition and further development of the concept and the design of other prototypes. The more there are of these evaluations, the stronger the concept of design, which benefits the overall outcome of the project.
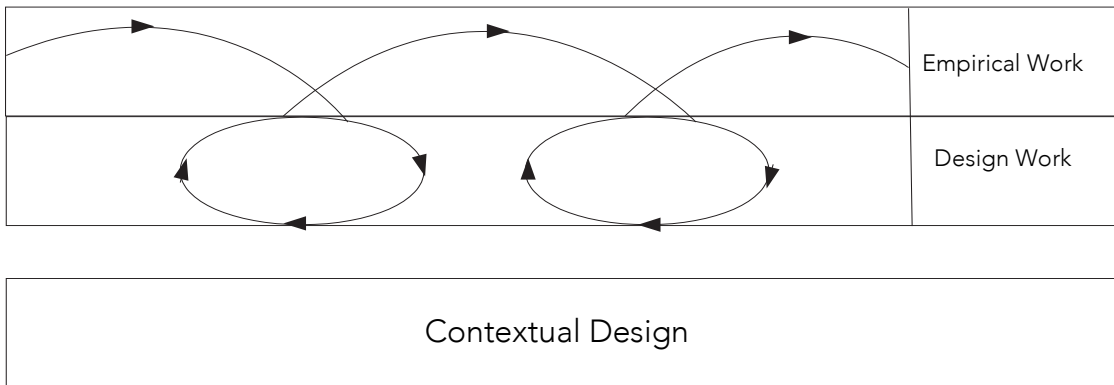

Figure 5.3. An illustration of the research process

Discussion & Implications for Research

HCI research is a growing field of study with many of the theories and methods imported from other subject areas (Rogers, 2004). Although these theories and

methods have helped the HCI discourse to expand, it has had a limited effect on the practice of interaction design (Rogers, 2004). Many of the approaches developed in HCI have been criticized because they are too time consuming, too difficult to learn, too abstract and theoretical and do not lead to the desired outcomes (Stolterman, 2008). Highlighting the research process tailored for the InPhAct project could contribute to this discussion. The research process illustrated in Figure 5.3 is the methodological contribution of this thesis. Designing a research process is the initial step in executing any project work. The design process used in this thesis can serve as an example of how methodological practices can come together to facilitate the contextual understanding of phenomena. The three approaches used in this process were selected based on the requirements of the InPhAct project. This process indicates how it is possible to use contextual design (Beyer & Holtzblatt, 1997) thinking as the backbone of our methodological approach. This research process demonstrates how to use different methodological practices while applying contextual thinking. For example, I benefited from undertaking observational ethnography and prototyping at the same time in a real setting, leading to the development and redefining of concepts. This approach avoided becoming too complicated, theoretical or abstract as it was implemented one step at a time.

This research process has two characteristics that can be discussed in detail. Initially, it highlights how observational ethnographic studies, concept development and prototyping can be intertwined forming a contextual design approach to create a tailored method that is suitable for understanding the context of increasing physical activity in office workspaces. Thus, this is a successful example of the use of a contextual design approach. Second, it demonstrates that the contextual design approach does not need to be restricted only to redesigning. In fact, in the research process described in this thesis, I have shown how we can redesign work by investigating the office work setting through the use of prototypes. Furthermore, I have described how the presence of two prototypes, the "*NEAT Lamp*" and the "*Talking Tree*", delivered changes in the office workspaces. Individual changes in the behavior of the office workers were associated with acknowledging the importance of taking exercise breaks (pausegympa). More importantly, there were social changes, such as how other office workers reacted to their colleagues while interacting with the prototypes. These social changes once more highlight the importance of the social aspect of work that encouraged us to develop the "*NEAT Lamp*" concept and produce the "*Talking Tree*" prototype. In fact, work is a social practice, and in this thesis I

have aimed at redesigning it by defining its design space and investigating it by adding actual prototypes to the office to influence the social setting. I hope that by highlighting this process, I can provide an inspiration and example for future researchers undertaking contextual studies and design in general. In addition, I hope that this research process can inspire researchers who are dealing with similar challenges relating to increasing physical activity among users in everyday settings.

Limitations & Future Steps

When conducting any project there are always a number of limitations and shortcomings that influence the outcome. For example, in this work I would have preferred to evaluate the "*NEAT Lamp*" prototype in the same setting as the first observational ethnographic study was conducted. In addition, I would have chosen to conduct a prolonged observational ethnographic study to evaluate the "*Talking Tree*" that unfortunately was not possible due to a lack of time. There were also specific limitations in the "*Health Co.*" study, such as how the Fitbits were used and the fact that other sensitive and specific tools like accelerometers (e.g. ActiGraph and activPAL) could have been employed, which may have produced more reliable quantitative data sets. It would also have been desirable to change the sensors of the "*NEAT Lamp*" prototype and avoid changes in the time plan of the study as described in paper III.

However, despite the limitations and the problems associated with the design process, the outcomes presented suggest future ways of conducting similar studies, such as exploring the design space discussed earlier by designing more prototypes and evaluating them in actual settings. In addition, it would be interesting to examine achieving an appropriate balance in the design space presented herein? Furthermore, if the idea of redesigning work is now limited to new configurations of IT such as the "*NEAT Lamp*" and the "*Talking Tree*", then we may wish to investigate how these designs affect work in offices in the long run. It would also be valuable to examine how similar designs affect both individuals and social interactions of office workers. Finding ways to redesign work and exploring modern definitions of what work is about also require some attention. Finally, it would be valuable to examine how we transition from our old approach to designing work to a new design paradigm that acknowledges "*Moving Bodies*" in the workspace and how these changes can be applied.

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Appendix I

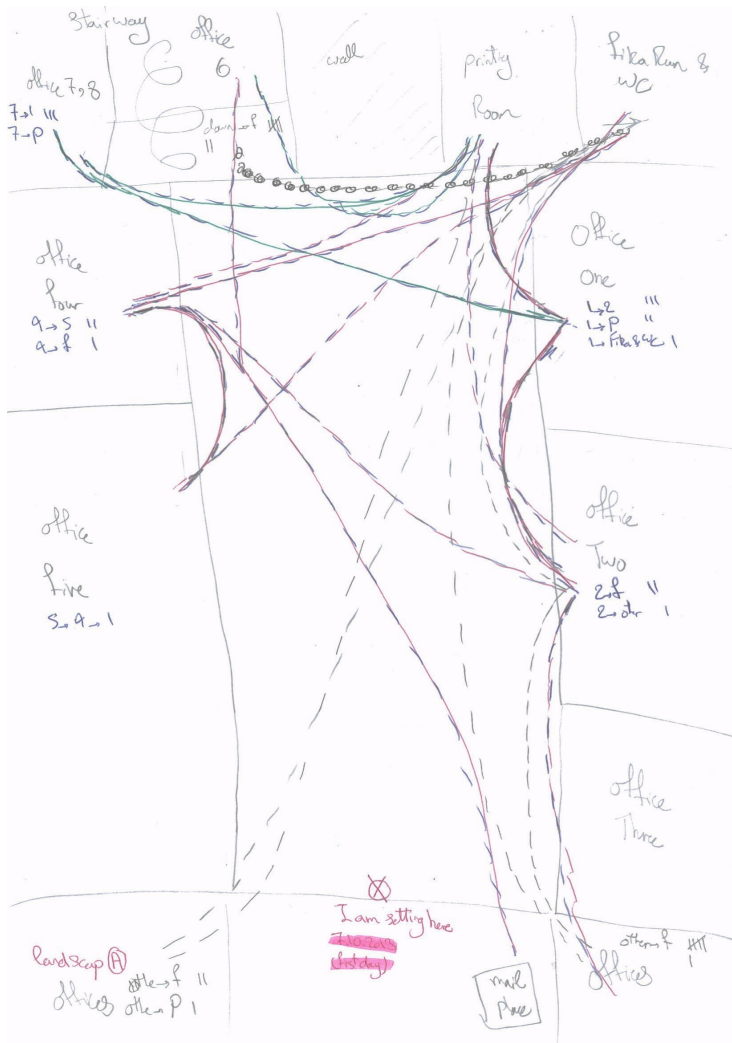Sample of some of the data collected in the observational studies.

Figure. AI.1. Data gathered in the 1st day of observational
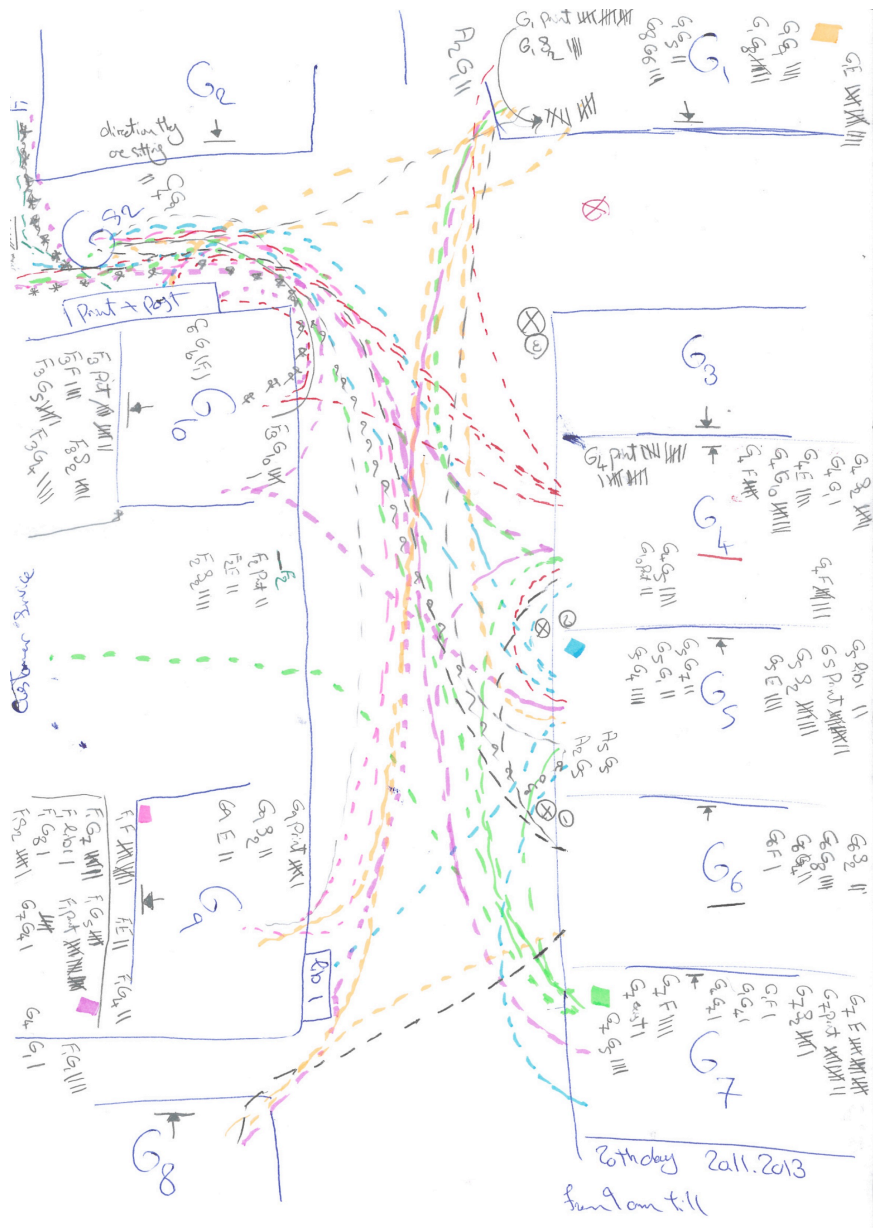ethnographic studies in the "*Housing Co.*"

Figure. AI.2. Data gathered in the 5th day of observational ethnographic
studies in the "*Housing Co.*"

Figure. AI.3. Data gathered in the 12th day of observational ethnographic studies in the
"*Housing Co.*"

Figure. AI.4. Data gathered in the 20th day of observational ethnographic studies in the *"Housing Co."*

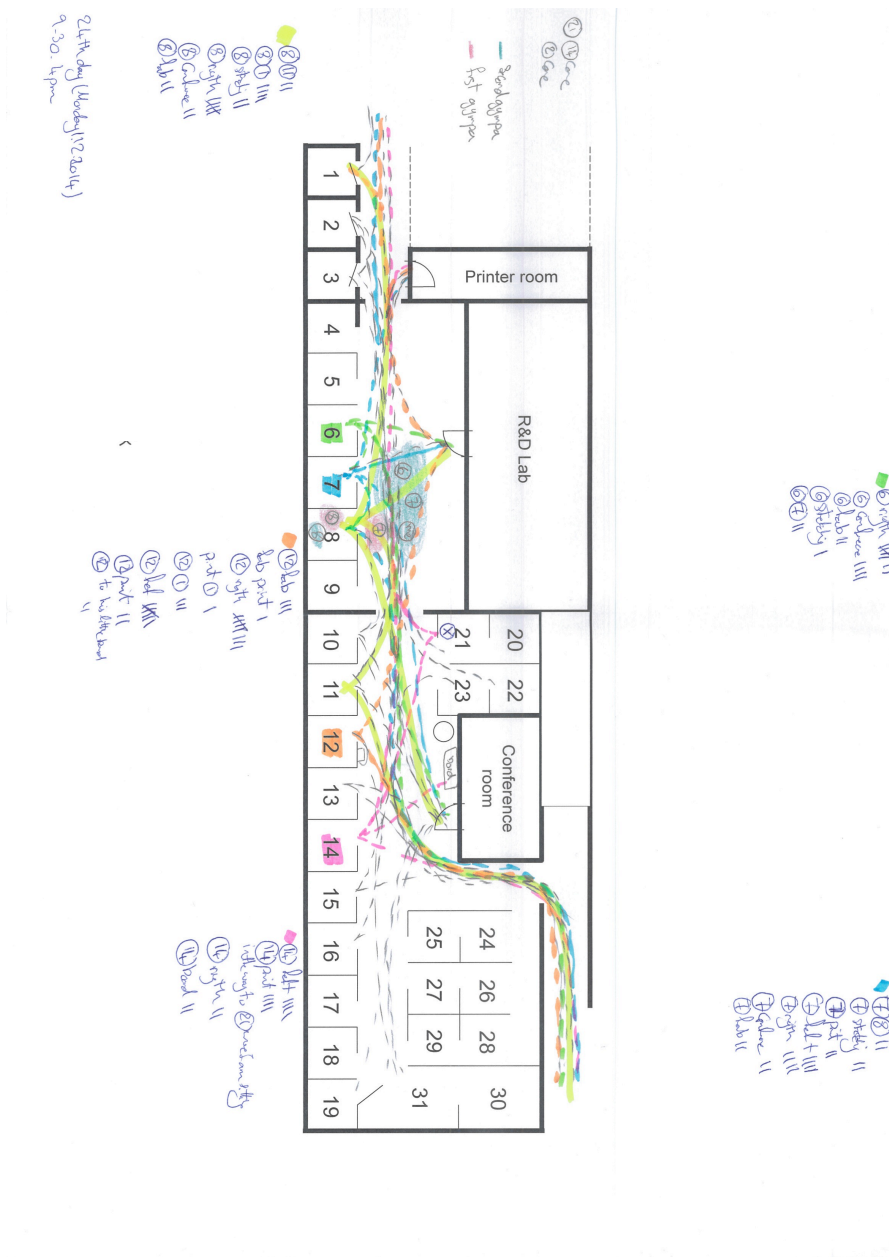Figure. AI.5. Data gathered in the 2nd day of observational ethnographic studies in the "*Health Co.*"

Figure. AI.6. Data gathered in the 24th day of observational ethnographic studies in the "*Health Co.*"

Appendix II

The questions asked in the second observational ethnographic study, the "*Health Co.*".

The Main Theme for the "*Health Co.*" Interviews

This interview will be conducted in three main parts. It will start by the relation of the participant to the technology and the lamp in general. Then we will fallow by the effect of the lamp in their relation and how they reacted to it. And in the last part the questions are more focused to their relation to work. Apart form the main themes of this interview, in the begging of he session I will try to gather some basic background information. Based on the background data we can acquire understanding of the participants' activity level and their understanding of the hazards of prolonged sitting.

A. Background

1. How is the nature of your work and what do you do mostly?
2. How much are you aware of the hazards of prolonged sitting?
3. How much do you work in sited position?
4. Have you ever used any sort of booster breaks?
5. How about personal informatics?
6. Generally are you aware of side effects of prolonged sitting?
7. Do you do any exercise and how many hours do you exercise per week?

B. Relation to Technology

1. Can you please describe your experience with this particular artifact (Lamp and the Fitbit)?
2. What was easy about working with this lamp?
3. What was hard about using this artifact?
4. What did you liked about the lamp?
5. Where there anything that you hated about the lamp?
6. If you had the ability to change this lamp, what would you have changed?

C. Reflection on Activities while Interacting with the Lamp and the Fitbits

1. Did using the Lamp and the Fitbit affected you at any level? If so how was it could you please describe? And if not would you please state why that could be?
2. If you were walking more would you please describe how they were and were they in the morning or in the afternoon?
3. Did it affect others? Had it happened that others in the workspace come to you and ask questions or comment in these technologies?
4. Where there any group pressure visible? (Specially because of its reflection on the celling)
5. Would you please describe one working day when the lamp and Fitbits where available?
6. How doses this day differed from other days before the study? Why?
7. Have you been effected by the lamp or the Fitbits in general? Why?

D. In relation to work

1. Did you ever have an awareness of these artifacts while working? How much these artifacts either the lamp or the Fitbit were present for you?
2. Which one of them affected your work? Why?
3. How did using these technologies affected the way your work was organized?
4. Considering the fact that the lamp turns on every 20min or so, did this changed the way you work? How?
5. How did time being chunked affect your work?
6. In general will you miss it or you are happy that you have got rid of it?