How it Feels, not Just How it Looks

Towards an Understanding of Kinaesthetic and Proprioceptive Experiences of Interaction with Technology

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A Thesis submitted for the Degree of Doctor of Philosophy in Computing Sciences

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CERTIFICATE OF AUTHORSHIP AND ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abstract

Movements of the human body are involved in all our interaction with technology, and these movements have kinaesthetic and proprioceptive aspects to them. This thesis addresses kinaesthetic and proprioceptive experiences in technology interaction, and develops an empirical grounded concept, the feel dimension, an articulation of the different aspects of this experience. The thesis discusses why movement understandings should be a part of interaction design practice, and how to work with these understandings through a set of design questions for exploring kinaesthetic and proprioceptive experiences in a technology design situation.

The questions in this thesis address how and what makes a technological system good to use from the perspective of the kinaesthetic and proprioceptive senses. These questions were explored in three studies in which I examined the *use* of technology enabled through movement of the body, the *experience* of moving, and movement as a material for *design*. Movement was analysed from three different points of view, as an *object for investigation*, as *subjective experience* and as a form of *knowing*. The outcome of the thesis suggests that what makes a system good to use, from the perspective of the kinaesthetic and proprioceptive senses, is an understanding of how the four concepts tangibility, proximity, dynamics and Merleau-Ponty's body schema (1962) influence our kinaesthetic and proprioceptive experiences. Synthesised, these four concepts form the foundation for the feel dimension, the main contribution of this thesis. The feel dimension attempts to define the role our kinaesthetic and proprioceptive senses play in experiencing technology interactions from the point of view of people moving and acting. Additional contributions include:

- Three empirical studies exploring different aspects of movement, which highlight the use of technology enabled through movement of the body, the experience of moving and movement as a material for design.

- Insights into and extension of the nature of user experience by introducing kinaesthetic and proprioceptive experiences as an experiential quality.
- Alternative phenomenologically informed methodologies on how to collect and approach data about kinaesthetic and proprioceptive experience and the use of multiple perspectives in the analysis of this data.
- Suggestions for how to understand movement as a part of interaction design practice. That is, how to be able to design technology interactions based in understandings of movement through performance and observation of movement.
- A set of design questions following from the feel dimension that can be used to organise and support design decisions when designing for kinaesthetic and proprioceptive experiences.

Chapter 1
Introduction

This thesis aims to contribute understandings of kinaesthetic and propricoeptive experiences, as an experiential quality of interaction with technology, to the study and design of technology. In this introductory chapter I describe what I mean by kinaesthetic and proprioceptive experience and my motivation for embarking on this research. I relate this motivation to the theoretical, methodological and empirical approaches for the thesis work.

The remainder of the chapter presents a short version of the thesis: the research questions, the aims, the evolution of the research studies, the thesis argument, the scope and my contribution to the emerging paradigm of movement-based interaction. The chapter ends with an outline of the thesis and a list of publications generated from the research.

> *It is to me an open question how the psychology of* Kinesthetic Thinking *should be studied further. From a psychological point of view, the nature of* Interaction Gestalts *and* Kinesthetic Thinking *is only pointed to here. How should the experiments be set up, and how should the results be interpreted? Will it be possible to identify simple gestalt principles in the kinesthetic domain similar to those in the visual domain? If so, will these principles be as applicable to interaction design as the gestalt principles of the visual domain and the insights about visual thinking have been to graphical design?* (Svanæs 2000, p. 246, emphasises in the original)

> *Kinaesthetic: pertaining to movement sense; for example to the perception that one's leg is moving or being moved without looking.* (Cole 1995, p. xix).

> *Proprioception: perception of the position, state and movement of the body and limbs in space. Most of the information for this perception arises from muscles and joints, but in the face and hands cutaneous sensation is important.* (Cole 1995, p. xx).

In many of the movements required for our everyday interaction, for example walking, swimming effortlessly, pouring a glass of juice or even skilful typing, most people do not consciously have to use the kinaesthetic and proprioceptive senses. The movements used to carry out these interactions and the accompanying movement experiences can be described as *fluent, skilful, poised* and even *with flare*. Yet kinaesthetic and proprioceptive perceptions are fundamental aspects of the movements used to carry out these interactions. In fact, kinaesthetic and proprioceptive perceptions are so fundamental they are very often taken for granted, yet without it we would be able to do little. Without kinaesthetic and proprioceptive perceptions we would not be able to stand upright without the use of vision, or tell how to move an arm to reach something behind us[1].

Movements of the human body are of course involved in all our interactions with technology. Clicking *OK* to print, entering an appointment into a PDA, buying a chocolate from a vending machine, entering a building through an automatic door, playing a computer game with a game controller, withdrawing money from an ATM and adjusting the volume on an MP3 player embedded in a ski jacket; all these interactions require that people perform certain movements so that the interaction with technology can take place. Using movements of the body, we interact with technology

[1] The definitions of kinaesthetic and proprioception at the beginning of this chapter describe kinaesthetic as pertaining to movement sense and proprioception as pertaining to perception of position, state and movement. These two concepts are very closely linked, yet not entirely the same so for my purposes here, I will, in the remainder of this thesis, use both terms to indicate that I am referring to the senses that allow us to know both our body position and the movement of our limbs.

with our hands and feet (e.g. PDA with a touch screen or pressure sensors in a game) with technology on our bodies (e.g. MP3 players in a ski jacket), through devices that control technology in the environment (e.g. a remote control or game controller) and technology located in the environment around us (e.g. automatic doors and GPS). Though some of these movements and movement experiences in the interactions with technology can perhaps be described as *fluent, skilful, poised* and *with flare*, an equal number can probably be described as *awkward* or *hesitant*. People can experience skilfulness, for example, when typing, but rarely the gracefulness described above. *Flare* is generally not appreciated by technology, and *fumbling* rather than *fluency* might best describe our interactions and experiences.

The experience of moving in any of the interactions described above has kinaesthetic and proprioceptive aspects to it. As an interaction designer, I found that with the language available to me in human-computer interaction (HCI) I could talk about interaction in terms of usability and usefulness, with regards to efficiency and functionality, or lack thereof. However, I found that there was more than efficiency to the satisfaction felt when I encountered a smoothly operating motion-sensing paper towel dispenser and similarly, a visceral frustration with awkward computer game experiences. These additional aspects seemed relevant to overall user experiences with technology, but seemed to fall beyond language and labels available in HCI, interaction design and user experience literature.

In this research project therefore, I draw on my background as an interaction designer as well as my experience as a movement practitioner and observer of movement. By *movement practitioner*, I mean a person who has had an active and reflective engagement with movement, through moving and observing movement over a period of time. My history as a movement practitioner precedes my involvement in the evaluation, teaching and design of technology. I mention this because I believe it helps explain the motivation for this research, as well as contextualise the outcomes.

1.1 User Experience in Technology Interactions

> *How can kinaesthetic and proprioceptive experiences as an experiential quality be accounted for in technology design and the study of technology use?*

This is the overarching question this thesis addresses. The inclusion of the kinaesthetic and proprioceptive senses can contribute to expanding definitions of user

experience in technology design and the study of technology use. The questions of *how* kinaesthetic and proprioceptive senses can support or augment our senses is an underutilized consideration in technology design and remains uncommon in the study of technology use. This thesis tries to shed light on this topic by providing suggestions for *why* this topic should be considered, *how* this topic could be approached, and by *generating articulations* of the role our kinaesthetic and proprioceptive senses play in experiencing technology interactions from the perspectives both of a person using technology and of a designer of movement-enabled interactions.

1.1.1 Background

In 2001, I read a thesis entitled *Understanding Interactivity: Steps to a Phenomenology of Human-Computer Interaction* by Dag Svanæs (2000). Among many interesting things in this thesis was his suggestion that

> *...dance classes should be included in the curriculum of interaction designers...* (Svanæs 2000, p. 10).

This statement caught my attention. I found the idea wholly intriguing and it instinctively resonated with me. Drawing on Gardner's (1993) theory of multiple-intelligence, Svanæs says:

> *In the same manner as students in interaction design are often advised to take classes in drawing and visual thinking, the students should also be encouraged to take classes in dance, choreography, Tai Chi Chuan, or in other practices that help develop their bodily-kinesthetic intelligence.* (Svanæs 2000, p. 228).

I asked myself the question, *How can kinaesthetic and proprioceptive experience of movements of the human body be accounted for in technology design and the study of technology use?* This question continued to nag me. If this was to be investigated further, how would one go about it?

Interactions with technology can be interesting, frustrating, useful, easy, challenging, demanding, fun and strange. In HCI, the descriptions we attach to the *qualities* of the interaction experience are usability, learnability, effectiveness, efficiency, user satisfaction, consistency, but also fun, aesthetic, repetitive, fluent and so on. Regardless of the label, interactions in some way engage and resonate with people, they intrigue and captivate, and they frustrate, bore or delay.

Sharp et al. (2007) describe user experience as:

> *...it is about how people feel about a product and their pleasure and satisfaction when using it, looking at it, holding it and opening and closing it. It includes the overall impression of how good it is to use right down to the sensual effect small details have on them, such as how smoothly a switch rotates or the sound of a click and the touch of a button when pressing it.* (Sharp et al. 2007, p. 15)

Seminal works in HCI underlying the more recent work on user experience, for example, by Suchman (1987) and Bødker (1991) characterise successful interaction in terms of the absence of breakdowns in communication between people and technology. In this thesis, I discuss kinaesthetic and proprioceptive experiences and breakdowns in communication that are perceived by and through these senses. Transposed to kinaesthetic and propricoeptive experiences and user experience in technology interactions, this research then is about *how interactions with technology might engage with our kinaesthetic and proprioceptive senses,* and *what potentially useful labels, concepts for thought, reflection and articulation can we attach to these interaction experiences*.

Of the human senses, HCI engages mainly the visual, auditory and tactile senses. Research, such as the case describe by Cole (1995), has shown that our kinaesthetic and proprioceptive senses are integral to how we perceive and experience the world[2]. Hence, it is important to account for it in HCI. An increasing number of technologies and concepts rely on movements of the body to enable interaction. There is a growing number of technologies that both *make* and *allow* people to move, or have the potential to make and allow people to move in ways other than those required, say to operate technology using a keyboard and mouse. The ability of technology to detect and respond to interaction through movements is also evolving. We can enable interaction through mere presence in a location, through different movements and, to some extent, by the way in which we perform movements (e.g. fast/slow, smooth/erratic movement with Nintendo® Wii™). In conjunction with this development, technology designers, artists and academics have started to consider explicitly the movements used in technology interactions for the purposes of evaluation, design inspiration and implementation of movement enabled systems, e.g.

[2] Cole (1995) describes the case of Ian Waterman who lost all kinaesthetic and proprioceptive sense below the neck. Gradually Waterman has retrained himself to be able to live an independent existence (i.e. walk, eat, work etc). However, since there is no feedback from his limbs, it requires that he consciously monitor every movement by sight to work out where his limbs are.

Djajadiningrat et al. (2004), Larssen et al. (2004), Schiphorst and Anderson (2004), Jensen et al. (2005), Hummels et al. (2007), Larssen et al. (2007a), Loke (2009) and Moen (2007), to mention a few. These include the impact, appropriateness, usefulness, suitability and experiences of these movements. Some of these researchers and designers in HCI and interaction design also consider the kinaesthetic and propricoeptive aspects of interactions with technology, e.g. Svanæs (2000), Schiphorst and Andersen (2004) Djajadiningrat et al. (2004), and Moen (2007). The discussion in this thesis will not be limited to these or particular types of applications. Instead, I shall discuss interactions, in general, from the point of view of kinaesthetic and proprioceptive experiences.

1.2 Research Design

This research will contribute understandings of kinaesthetic and proprioceptive experiences and movement to interaction design and the study of use. In my search for approaches for this research, I decided to frame my inquiry from the perspective of Merleau-Ponty's phenomenology (1962). As the theoretical background for the research, this then provides a particular set of philosophical foundations and assumptions on which I have based my methodological approach and the empirical means. Figure 1.1 shows an overview of my research, illustrating the relationship between the theory and empirical explorations.

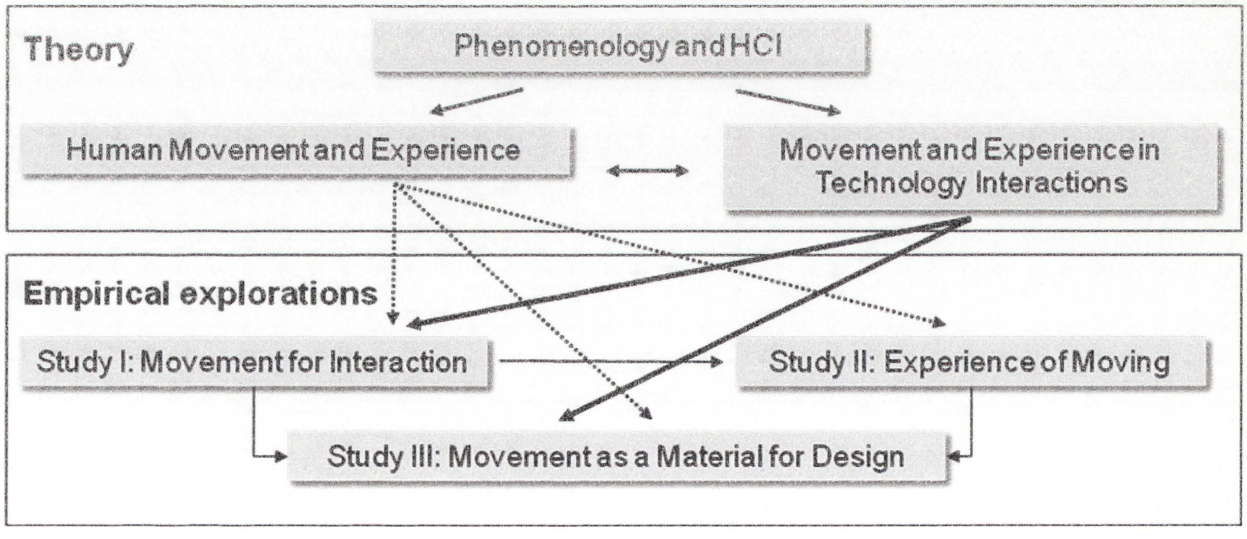

Figure 1.1: Relating the three studies to theory

The next sections briefly describe my research questions (1.2.1), the theory forming the foundation for this research (1.2.2), the rationale for the overall methodological

approach and the methods chosen (1.2.3) and the three studies I undertook to address my research questions (1.2.4).

1.2.1 Research Questions

The main topics of the thesis are kinaesthetic and proprioceptive experiences in the design and use of technology, and my research attempts to answer the question:

> *How can kinaesthetic and proprioceptive experiences as an experiential quality be accounted for in technology design and the study of technology use?*

That is, how can kinaesthetic and proprioceptive experience be defined, described, analysed and represented in relation to technology design and the study of technology use? From this main question, a number of sub-questions follow:

> *1. What terminology and what methods are available in HCI for studying movement, in general and kinaesthetic and proprioceptive experience, in particular? (literature)*
>
> *2. How can the role our kinaesthetic and proprioceptive senses plays in experiencing interactions be accessed? (methodological)*
>
> *3. What aspects of kinaesthetic and proprioceptive experiences could be relevant for understanding technology use and interaction design? (theory building)*

As these questions show, there is extensive unexplored territory, of both technological and less technological character, surrounding the main topic. The questions address theory building, literature and methodological or design-oriented aspects. The research to be carried out, therefore, became exploratory in character. These research questions necessitate that I in the course of the thesis also discuss the following:

- Why it is important to account for the kinaesthetic and proprioceptive senses in HCI;
- What kinds of understandings of human movement can provide useful perspectives for the study of kinaesthetic and proprioceptive experience within technology design and the study of technology use; and
- How these understandings (representations) can be incorporated into interaction design.

My hypothesis was that a more thorough understanding, and better descriptions and representations of the kinaesthetic and proprioceptive senses would aid our overall

understanding of technology designs and help us develop more fluid interaction experiences with technology.

1.2.2 Theory

I am locating myself in a reflective-critical tradition of HCI, aligning myself with phenomenologically motivated theoretical perspectives on how to study the relations between embodied actions and technology design and use (e.g. Suchman 1987, Robertson 1997a and 2002, Dourish 2001, Svanæs 2001, Hornecker 2005). Merleau-Ponty's phenomenology places human perceptions and action at the centre of the lived experience, and a phenomenological perspective can inform technology design and the study of technology use through its analysis of the body's role in perception. Merleau-Ponty is acknowledged in HCI and interaction design as a phenomenologist focusing on the lived, perceiving and moving body (Robertson 2002).

1.2.3 Method

Phenomenological research is the study of essences[3]; it is about what is actually experienced in our everyday lives. In phenomenological research, the researcher tries to uncover and describe the internal meaning structures of lived experience.

As a research method, phenomenology suggests how things should be approached, dealt with and understood. Working within a phenomenological tradition, studying kinaesthetic and proprioceptive experiences and human movement calls for empirical grounding in actual lived experience. A study of experience within the phenomenological tradition suggests setting up situations where the essence of an experience can be grasped or understood by studying the particulars or instances as they are encountered in lived experience. In order to study kinaesthetic and proprioceptive experiences of movement as lived experience, *participant observation* and *interviews* were chosen as central methods. By combining participant observation and interviews, carried out in the field, I addressed the issue of potential inconsistencies between what people do and what they say they do. Such inconsistencies can often be attributed to the fact that people often do not access implicit knowledge associated with certain activities (Blomberg et al. 1993). Kinaesthetic and proprioceptive experiences are part of our everyday lives, though

[3] In this research, the term "essence" is used to indicate the unique and distinguishable intrinsic character of a thing that can be uncovered.

when we are asked to reflect on and talk about these experiences, we are not always able to provide comprehensive descriptions. By participating in as well as interviewing people about their activities and their experiences in these activities, I was able to combine my participants' experiences with reflection on my own kinaesthetic and proprioceptive experience; this became a valuable part of my research.

1.2.4 Studies and Evolution of Research Focus

The three resulting studies on which this thesis is based utilise a range of approaches, some common to HCI, others borrowed from or inspired by domains such as ethnography. Each phase of the research was used to refine the research questions and to determine the appropriate setting, methods for data collection and analysis for the next study. The evolution of the studies and their interpretation follow. Together, the framing of the overall research question and the interpretation of the studies form the basis for the theory generation in the thesis.

As a starting point, the first study was conducted in order to address the question, *What methods are currently available in HCI as ways of describing and representing interaction with technology enabled through movement?* Through this study it was discovered that HCI does have ways of describing and representing movement, and, in particular, methods that address the movement of technology, but few that address the movements people make, and even fewer that address kinaesthetic and proprioceptive experiences.

From literature and this study, *tangibility*, *proximity*, *dynamics* and *body schema* were identified as concepts relevant for describing both movements and kinaesthetic and proprioceptive experience. The focus of the second study was defined by the understandings and insights gained from the first study, combined with emerging literature that had started to consider the impact, appropriateness, usefulness, suitability and experiences of moving in relation to technology (e.g. Djajadiningrat et al. (2004), Schiphorst and Anderson (2004), Jensen et al. (2005), Hummels et al. (2007), Larssen et al. (2007a), Loke and Robertson (2009) and Moen (2007)). This literature explores the experiences of moving for the purposes of evaluation, design inspiration and implementation of systems.

The second study aimed to address experiential descriptions of moving, as this aspect of movement was not captured with the methods used in the first study. Further, the study asked about the nature of knowing and understanding generated through experiences of the moving body, and what this type of knowing could mean in relation to interaction design. The kinaesthetic and proprioceptive experience of moving, as described by the participants in this study, suggested that the knowing required and involved in doing movement was a *knowing how* and that this knowing is *felt* and achieved through moving. The performance of a bodily practice is the way you display your knowing experientially. The complementary elements of *knowing* and *doing,* rather than *knowledge* as a *given*, I interpreted as the meaning making that takes place in our ongoing movement dialogue within the particular circumstances in which a movement practitioner acts.

In the second study, the continuum of knowing or *degrees of knowing* was developed as a distinction between bodily understanding and performance, when knowing is constituted in doing. The third study then became an exploration of one extreme of this continuum; what it means to performing practice when movement is your material for design. In addition, the third study picks up on and further explores the concepts, *tangibility, proximity, dynamics* and *body* schema identified in the review of the literature.

Figure 1.1 (above) shows an overview of my research, illustrating the relationship between the theory and empirical explorations. My phenomenological grounding influences the way I look at the theory about *human movement and experience* and *movement and experience in technology interaction*. Study I drew on theory from both these areas; the second study developed from study I and it drew mainly on theory about *human movement and experience*. While in study III, the first study, the second study and theories from both *human movement and experience* and *movement and experience in technology interaction* came together to form the foundation.

It should be added that in the three studies in, I focus on a type of movement which could be called movement for movements sake, i.e. movement takes place as part of playing a game or performing sports/exercise. It can be argued that these movements have a different motivation than movements used when, for example adjusting valves in a factory, where movements would be seen as means to an end. This distinction,

between movements for movements sake and as means to an end, becomes blurred when discussing this topic with people who are very aware of their bodies. I therefore, consider insights gained from my studies as relevant beyond this distinction, but outside the scope of this thesis.

The evolution of the three studies is presented in its entirety and discussed further in Chapter 3; the studies themselves are discussed in Chapters 4, 5 and 6, respectively. From the empirical work, the nature of kinaesthetic and proprioceptive experiences as an experiential quality for interaction design and the study of technology use, as emerging from this research is presented in Chapter 7.

1.3 Contributions

This thesis is an investigation into the various kinds of experiences and relations that emerge from paying attention to kinaesthetic and proprioceptive experiences when people move. It is also about how including these considerations in interaction design may contribute to and challenge the concept of user experience within HCI. The purpose of this is to provide designers with the conceptual means to take kinaesthetic and proprioceptive experience into consideration when designing, especially for movement enabled interaction. My hope is that these concepts will be used to develop more fluid interaction experiences than those confronted by users today.

See Figure 1.2 below for a summary of the thesis' contributions. Each of the contributions is described in the following sections.

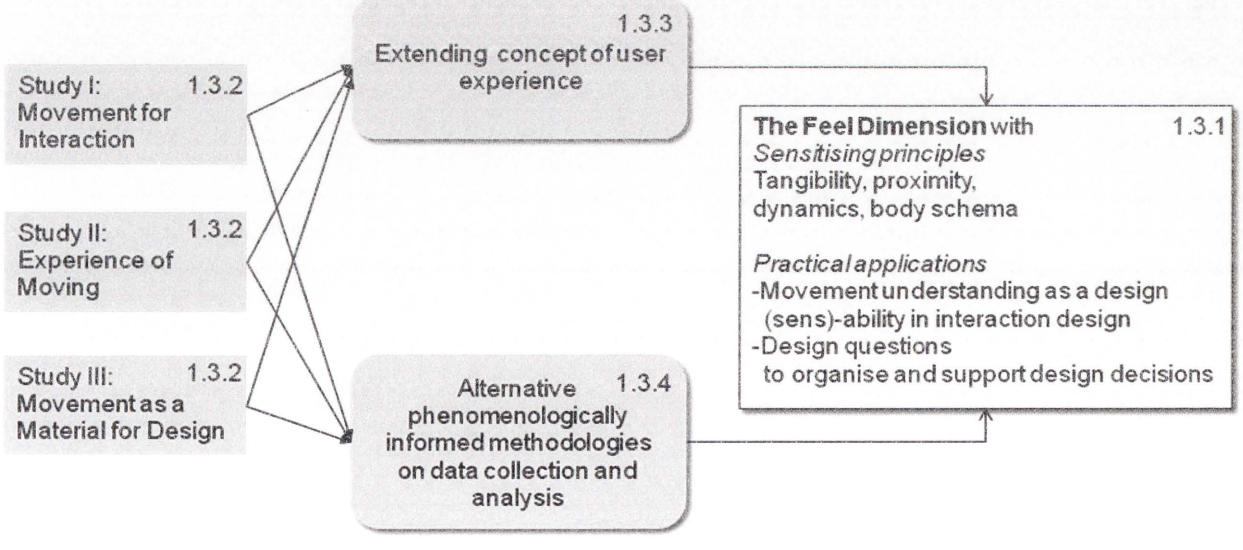

Figure 1.2: Thesis contributions

1.3.1 The Feel Dimension and its Practical Implications

Based on the three empirical studies, the main contribution of this thesis is the articulation of the empirically grounded concept the *feel dimension*.

> The feel dimension is an articulation of the role our kinaesthetic and proprioceptive senses play in experiencing technology interactions from the point of view of people moving and acting.

The feel dimension of technology interactions is the process of establishing relationships with the space and the things[4] in the space around us using our kinaesthetic and proprioceptive senses. The experiential distinction I am highlighting in this work lies in paying attention to the way in which we attend to the things we establish a relationship with. This distinction is important as it arises out of my particular perspective of proposing conceptual tools for technology design based on phenomenological accounts of the experience of things and establishment of people/thing relationships. The feel dimension is to be understood through a set of sensitising principles, tangibility, proximity, dynamics and body schema, as aspects that can help us understand how and what makes an system good to use from the perspective of the kinaesthetic and proprioceptive senses. I describe this further in Chapter 7.

As practical applications of this contribution:

- I make suggestions for the practice of interaction design about movement understanding as a design (sens)-ability in interaction design, and
- I provide a set of design questions for the feel dimension that can be used to organise and support design decisions.

Movement understanding, as part of interaction design practice, describes what it could mean to pay attention to the feel dimension as an experiential quality for the practice of interaction design. I suggest that successfully incorporating understandings of kinaesthetic and proprioceptive experiences into interaction design requires the

[4]Note: In this thesis I have deliberately chosen to use the non-specific term *thing* interchangeably with technology, because I want to refer to and believe my discussion applies to, non-specific objects.

ability to perform, create, observe and evaluate movement, and to being able to design based in this understanding.

The design questions following from my exploration of feel dimension are meant to be used as aids by interaction designers who wish to develop an appreciation for the subtleties of designing for the feel dimension, as well as to organise and support design decisions. The questions suggest issues to consider when choosing movement for interaction, for aspects of chosen movements and for movements in relation to sensor technology.

The research in this thesis was conducted with the aim of understanding a phenomenon, though with the overall aim of contributing to the design of technology and the study of its use. The aim of this thesis is not to design new technology, what this thesis contributes is a conceptual tool with ideas and methods for how to choose and evaluate movement for technology interactions that support kinaesthetic and proprioceptive experiences,.

1.3.2 Empirical Studies

Research conducted for this thesis included three empirical studies of different aspects of movement, highlighting the *use* of technology *enabled through movement* of the body, the *experience of moving* and *movement as a material for design*. The studies inform interaction design as they serve as starting points for developing an understanding of movement as input for interaction, and populate existing conceptual frameworks that provide tools to further the understanding of movement within interaction design.

1.3.3 Extending the Nature of User Experience

The nature of user experience was extended by introducing new insights about kinaesthetic and proprioceptive experience as an experiential quality. I also describe this experiential quality as a fluent movement interaction. Tangibility, proximity and dynamics and body schema were identified as important for this experiential quality.

1.3.4 Alternative Phenomenologically Informed Methodologies on Data Collection and Analysis

Finally, this thesis provides a methodological contribution to interaction design by demonstrating alternative phenomenologically informed methodologies on how to

collect and approach data about kinaesthetic and proprioceptive experiences, and the use of multiple perspectives in the analysis of this data.

1.4 Thesis Overview

This thesis starts from an overview of how movements of the body are used in current technology interactions, and ends with suggestions for incorporating experiential bodily understandings into interaction design. In this first chapter, I trace a path between the start and end point by first describing my motivations for embarking on this research, then the theory, the methodological and empirical means I used to conduct my research.

In Chapter 2, I present the theoretical foundations for this research based in phenomenological approaches in HCI. Different understandings of human movement and experience, from areas such as anthropology, choreography, dance, movement studies, somatic practice, HCI, computer vision and computerised recognition and analysis of human movement, are used to develop ways to study and understand movement and movement experiences in relation to technology.

In Chapter 3, the epistemological and methodological frameworks on which the research in this thesis is based are described. I present the evolution of the studies and the generation of theory. The overall methodological approach is explorative, experiential and qualitative. I also account for the data gathering techniques used as well as the method of analysis.

Chapters 4, 5 and 6 present the three studies which form the empirical basis for this research. In Study I, I examined the use of technology enabled through movement of the body using current frameworks in HCI for describing and representing movement in relation to technology (Chapter 4). Study II explored the experience of moving and the experience of learning movement in order to access descriptions and the nature of kinaesthetic and proprioceptive experience (Chapter 5). In Study III, I worked with professional movement practitioners in order to explore further what it means to perform movement practice as a craft and movement as a material for design (Chapter 6).

In Chapter 7, I present the *feel dimension*, a conceptualisation of kinaesthetic and proprioceptive experiences of interacting with technology. I also describe what I

believe to be the implications for interaction design practice of the feel dimension; interaction designers who are skilled performers and skilled observers of movement. This is developed into a set of design questions to be used when designing for kinaesthetic and proprioceptive experience as an experiential quality in interaction design.

Chapter 8 provides a summary of the thesis. I present some general reflections on the topic, and propose several directions for future research.

Throughout the thesis, the reader will encounter examples and activities labelled *Physical Exploration*, (as shown in Physical Exploration 1.1 below). These activities are provided as an additional way to approach the material presented in the thesis. The reader might choose just to read through these or alternatively engage with them by carrying out the activities.

Physical Exploration 1.1: Activity I - exploring effortless mastery

> You could think of previous experiences of walking through an automatic door, using an automatic hand drier, playing with the Nintendo Wii™, or attempting to trigger the correct recording on a wireless audio tour in a museum.
>
> Or the last time you used someone else's computer with a different keyboard from yours, perhaps a different layout, softer or harder keys or the mouse set to a higher or lower sensitivity?
>
> What are these experiences like? Are they smooth, frustrating, unsuccessful, efficient...?

1.5 Dissemination of Research and List of Publications

As a piece of written work, this thesis is my own work. In developing my work I have however had the opportunity to work with and befriend some remarkable individuals. My work has benefited from suggestions and revisions from supervisors, colleagues and friends, and from co-authorship. The work in Chapter 4, Study I, was carried out in collaboration with my colleague Lian Loke, who was also carrying out research for her PhD at the time. Both our theses benefitted from this collaboration and we co-authored several papers from this study. As such I refer to *we* when describing the work in this study and *I* when describing the latter two studies I conducted alone, and where I have taken the work in Study I further. Since carrying out the study together, we have both extracted the aspects relevant to our work and adapted it to our unique

research topics. My other co-authors include my supervisor Dr. Toni Robertson and co-supervisor Dr. Jenny Edwards.

Part of the thesis has been published already as sections of peer-reviewed conference and journal papers, this is particularly the case for Chapters 3, 4, 5 and 7. See below for URLs for the papers that are available online.

1.5.1 List of Publications

1. Loke, L., Larssen, A.T., Robertson, T. & Edwards, J. 2007, 'Understanding Movement for Interaction Design: Frameworks and Approaches', *Personal and Ubiquitous Computing: Special issue on movement-based interaction* vol. 11, no. 8, pp. 691-702.
(URL:http://www.springerlink.com/content/p0g587p80k4w/?p=c2414e5aa8eb4951a4b6b67a262ebab1&pi=20)

2. Larssen, A.T., Robertson, T., Loke, L. & Edwards, J. 2007, 'Introduction to the Special issue on movement-based interaction ', *Personal and Ubiquitous Computing*, vol. 11, no. 8, pp. 607-608. (Editors of the special issue)
(URL:http://www.springerlink.com/content/p0g587p80k4w/?p=c2414e5aa8eb4951a4b6b67a262ebab1&pi=20)

3. Larssen, A.T., Robertson, T. & Edwards, J. 2007, 'Experiential Bodily Knowing as a Design (Sens)-ability in Interaction Design', *DeSForM 2007: Design and Semantics of Form and Movement*, eds L. Feijs, S. Kyffin & B. Young, Newcastle, UK, pp. 117-126.
(URL: http://research.it.uts.edu.au/idhup/wordpress/wp-content/uploads/2010/01/Larssen_DeSForM2007.pdf.pdf)

4. Larssen, A.T., Robertson, T. & Edwards, J. 2007, 'The Feel Dimension of Technology Interaction: Exploring Tangibles through Movement and Touch ', *TEI 2007: Tangible and Embedded Interaction*, ACM Press, Baton Rouge, LS, USA pp. 271-278.
(URL: http://doi.acm.org/10.1145/1226969.1227024)

5. Larssen, A.T., Robertson, T. & Edwards, J. 2006, 'How it Feels, not Just How it Looks: When Bodies Interact with Technology', *OZCHI 2006*, eds J. Kjeldskov & J. Pay, Computer Human Interaction Special Interest Group (CHISIG) and ACM, Sydney, Australia, pp. 329-332.
(URL: http://research.it.uts.edu.au/idhup/wordpress/wp-content/uploads/2009/10/Larssen_OzCHI2006.pdf.pdf)

6. Loke, L., Larssen, A.T. & Robertson, T. 2005, 'Labanotation for Design of Movement-Based Interaction', *IE 2005: Interactive Entertainment 2005*, Creativity and Cognition Studios, Sydney, Australia.
(URL: http://research.it.uts.edu.au/idhup/wordpress/wp-content/uploads/2009/10/Loke_IE2005.pdf)

7. Larssen, A.T., Robertson, T., Brereton, M., Loke, L. & Edwards, J. 2005, 'Workshop: Approaches to Movement-Based Interaction', *Critical Computing: Between Sense and Sensibility: The Fourth Decennial Aarhus Conference*, Aarhus, Denmark

8. Larssen, A.T., Robertson, T. & Edwards, J. 2005 'Mechanics and Meaning: Methodological Considerations when Studying Movement in HCI', *Critical Computing: Between Sense and Sensibility: The Fourth Decennial Aarhus Conference*, Aarhus, Denmark.
(URL: http://research.it.uts.edu.au/idhup/wordpress/wp-content/uploads/2009/10/Larssen_AarhusWS2005.pdf)

9. Loke, L., Larssen, A.T. & Robertson, T. 2005, 'Gesture and Eyetoy™A Human-Centred Analysis of Movement-Based Interaction', *Gesture Interaction Workshop (NICTA)*, NICTA, Sydney, Australia.

10. Larssen, A.T., Loke, L., Robertson, T. & Edwards, J. 2004, 'Understanding Movement as Input for Interaction - A Study of Two Eyetoy™Games', *OZCHI 2004, Ergonomics Society of Australia (ESA) and the Computer Human Interaction Special Interest Group (CHISIG)*, Wollongong, Australia, p. (CD Proceedings).
(URL: http://research.it.uts.edu.au/idhup/wordpress/wp-content/uploads/2009/10/Larssen_OzCHI2004.pdf)

This research has also been accepted by and presented at APCHI 2004, NordiCHI 2004, OzCHI 2004 and ECSCW 2005 doctoral consortiums.

Chapter 2
Theoretical Foundations: The Moving Body and Experiential Qualities in HCI

The aim of this thesis is to contribute understandings of kinaesthetic and proprioceptive experiences, as an experiential quality of interaction with technology, to interaction design and to the study of technology use. As a theoretical foundation for this research, I take the position that the acting, perceiving body-subject is the means of our engagement with the world. For studying issues of design and use of technology, this situates my research in the phenomenological tradition.

The theoretical foundation of this research developed through an exchange between the questions I was asking and the various theories and concepts I encountered while conducting the research. I found concepts providing the language with which to articulate my questions, theories providing guidance on how to address my questions, and theories giving me a foundation from which to ask my questions. In this chapter, I present these theories and concepts. In turn, these allow me to develop the line of reasoning presented in this thesis.

This chapter is structured around three areas: HCI and phenomenology; different understandings of human movement and experience; and movement and experience in technology interactions. Different concepts and theories from these areas are used for reasoning about the study of movement enabling interaction with technology, and subjective experiences of movement in relation to technology. At the end of the chapter, I formulate the research problem for this thesis, thus pointing to the framing of my three studies in the next chapter.

> *The theory of the body is already a theory of perception.* (Merleau-Ponty 1962, p. 235)
>
> *If the body had been easier to understand, nobody would have thought that we had a mind.* (Rorty 1979, p. 239)
>
> *If one truly likes to design for movement-based interaction, one has to be an expert in movement, not just theoretically, by imagination or on paper, but by doing and experiencing while designing.* (Hummels et al. 2007, p. 677)

The quotes above frame the contents of this chapter. I start the chapter by situating myself in the larger field of HCI and the phenomenological research tradition in HCI. Phenomenology, as the overall theoretical approach taken in this thesis, provides a particular set of philosophical foundations and assumptions on which I base my research, and it further determines my methodological approach and the empirical means. In section 2.2, I outline three different understandings of human movement and experience: movement as an *object* for investigation, movement as *subjective experience* and movement as a form of *knowing*.

These three perspectives disclose different aspects of movement and allow for multiple ways to address and approach the study and understanding of movement and experience in relation to technology. I also utilise the generative power of multiple perspectives as a methodological tool. This is developed further in Chapter 3.

Section 2.3 uses the three perspectives to articulate different ways in which movement and experience are *used* in relation to technology, as well as methods for designing with and from experiences of movement (and the nature of skill involved in this). I conclude the chapter by describing what I mean by kinaesthetic and proprioceptive experiences as an experiential quality in interaction design (2.4), and by formulating the research problem for this thesis (2.5).

2.1 HCI: The Phenomenon of Interacting with Technology

This section describes how I approach the literature on the relationship between humans and computers. This relationship between people and technology emerges in situations and processes of use. The relationship is dependent on both people and technology. It depends on human perception and action, that is people communicating their intentions to the computer, using the human body and its movements for input or input devices, in such a way that the computer can interpret these intentions. This is

combined with output and output devices that provide relevant information from the computer in a form that people can perceive (Preece et al. 1994). Within the discipline of HCI, researchers often choose to study the relationship between people and technology (or parts of it) by focusing on input, processing by technology, output, human perception, or a combination of these. This is often done by exploring two general areas of concern for the study of interaction between people and technology: the *design* of products and processes, and the study of *use*. In HCI, we study use to inform design, but we also design, or prototype, in order to study use. The dynamic between design and use is continuously evolving and changing as technology evolves and use changes. Bratteteig writes about the relationships between design and use:

> *Design and use mutually influence each other, and it may be difficult to separate the "streams of influence" – even analytically.* (Bratteteig 2004, p. 211, quotations in original)

Much early HCI research focused on interaction in terms of issues of learnability, efficiency and performance. More recently, an increasingly large number of the papers and books published within HCI and related fields, such as computer supported collaborative work (CSCW), interaction design and participatory design examines:

- Overall experience of use (e.g. Buchenau and Fulton Suri 2000, Djajadiningrat et al. 2000b, Cheok et al. 2002, Battarbee 2003, Forlizzi and Battarbee 2004, Reeves et al. 2005, Kim et al. 2006 and Kozel 2007);
- Aesthetics of use (e.g. Hallnäs and Redström 2002, Petersen et al. 2004 and Moen 2005);
- Affective and social qualities of use (e.g. Halcomb et al. 1998, Picard and Klein 2002, Mueller et al. 2003, Paiva et al 2003); and
- Experiential qualities such as engagement, fun, the *playability* or *sociability* arising from a device or an interaction (e.g. Blythe et al. 2003, Gaver et al. 2004, Paulos and Beckmann 2006, Löwgren 2007a, 2007b and 2009, Wakkary et al. 2004 and 2008).

The use of the terms *user experience* and *use qualities,* as ways of articulating experiential properties of interactions, are attempts at extending common HCI measures, such as *usability attributes,* beyond objectively measurable attributes (e.g. efficiency, performance) to also include subjectively felt attributes of experience of use.

Another emerging trend relevant to this thesis, is research concerning reflective aspects of both design and use in HCI and interaction design (e.g. Gaver et al. 1999, Crabtree 2004, Löwgren and Stolterman 2004, McCarthy and Wright 2004, Sengers et al. 2005, Dunne 2006, Vetting Wolf et al. 2006 and Zimmerman et al. 2007). These works discuss reflective practices and are often influenced by methods in design and the arts. They advocate the integration of methods from these disciplines into both HCI research and practice.

A multitude of terms describing different aspects of design and use have developed to address issues of change in the design and use of interactive technology. Examples pertinent to my research include movement-based interaction, physical interaction, mobile computing, ubiquitous and pervasive computing, handheld computing, wearable computing, tangible interaction and augmented environments. Researchers in these areas often pay their allegiance to the *move beyond the desktop* (Weiser 1991). This *move*, into both new physical and social realms, has been enabled by advances in technology. For example, sensing technologies now allow interaction to take place with a range of different bodily movements (Bolt 1980, Couvillion et al. 2002, Headon and Curwen 2002, Thomas et al. 2002, Ängeslevä et al. 2003, Kim et al. 2004a, Kjølberg 2004 and the Apple iPhone™ 2007). To some extent, the ways in which movements are performed, for example, fast/slow, smooth/erratic movements (Nintendo® Wii™ 2006), are also used for interaction. Devices have become smaller and so can be used in new ways. We are no longer required to move to fixed places where our computers are, but we can carry our computers around with us as we move. Both these changes are relevant to the work in this thesis: the fact that interaction with technology can take place with a variety of movements, as well as the fact that we can carry computers with us. However, the way people interact with technology is still dependent on the cycle of input from humans and output from technology, all stages of which need to be at least partially successful to enable the interaction.

Hence, in this thesis, when trying to understand kinaesthetic and proprioceptive experiences of interaction, I am concerned with the both the phenomenon of *use* and the phenomenon of *design*. I am concerned with use, as in how we interact with technology, particularly as experienced through the kinaesthetic and proprioceptive

senses. At the same time, I am concerned with design, particularly the nature of skill involved in designing from and with experiences of movement.

2.1.1 Theoretical Stance: A Phenomenological Foundation

Alongside the dynamic between design and use, how we think about and conceptualise technology design and technology use also continues to evolve and change. As a field, HCI is interdisciplinary[1], drawing paradigms and techniques from the natural sciences, social sciences and the design disciplines. In contemporary HCI there are, therefore, many ways of conceptualising the relationship between people and computers, and hence, subsequently differing understandings of how it should be studied. As already stated, my research investigates kinaesthetic and proprioceptive aspects of interaction with technology; as such, it is aiming to understand a phenomenon.

Phenomenology, initially developed by Husserl, Heidegger, Merleau-Ponty and Sartre, is the philosophy of experience or lived experience (Husserl's term, *lifeworld* is also sometimes used). Phenomenological research is the study of the very nature of a phenomenon, or its *essence* (Merleau-Ponty 1962, p. vii); it is about what is actually experienced in our everyday lives. In phenomenological research, one tries to uncover and describe the various aspects of lived experience. As a method, phenomenology suggests how things should be approached, dealt with and understood. Working within a phenomenological tradition, studying kinaesthetic and proprioceptive experiences and human movement calls for empirical grounding in actual lived experience. For me, this means that what needs to be understood is the lived experience of people moving, using and designing technology.

Phenomenology was introduced into the broader areas of technology design and the study of its use by Winograd and Flores. In their book *Understanding Computers and Cognition* (1986), they critique the use of theories from artificial intelligence (AI) as the foundation for the design of technology. They suggest that Heidegger's (1962) theories might be a better foundation for studying both technology use and technology design. In their discussion, Winograd and Flores draw on work by Dreyfus, especially his book *What computers can't do* (1972). Dreyfus is also influenced by Heidegger

[1] The field of HCI can be considered both multi- and interdisciplinary. In my research I cross disciplinary boundaries, hence my use of the word interdisciplinary.

and Merleau-Ponty, and is one of the main interpreters of their philosophy today. Since 1962, both Heidegger (1962) and Merleau-Ponty (1962) have been used by design practitioners and researchers in HCI who are looking for theories for studying relations between human actions and technology design and use. In my research, I draw on Merleau-Ponty's phenomenology, as it is developed in his book *Phenomenology of Perception* (1962). Merleau-Ponty's contribution to phenomenology was to draw attention to the role of the body in perception; he has also been called the phenomenologist of the body (e.g. Moran and Mooney 2002).

Being in the world and *lived body* are some of the core concepts in Merleau-Ponty's philosophy underpinning the work in this thesis. The concept *being in the world* suggests that the fundamental way we existent in the world is through perception, and that this is a function of our always already embodied engagement with the world. We become aware of ourselves through interaction with our physical environment and with other subjects. The *lived body* is the body as it is experienced as an object among other objects, the perceiving subject is the mediating link to the world.

Complementing Merleau-Ponty's work, Gibson's theories about ecological perception (1966 and 1979) are influential in HCI for describing the role embodiment plays in human perception and our understanding of the world. By analysing the relationship between structures in the environment and human perception and action, Gibson describes how the meaning of an object is perceived relative to our bodies:

> *One sees the environment not just with the eyes, but with the eyes in the head on the shoulders of a body that gets about. We look at details with the eyes, but we also look around with the mobile head, and we go-and-look with the mobile body.* (Gibson 1979, p. 222)

Influenced by Gibson's work on visual perception, ecological psychologists have extended ideas of how the development of perceptual skills – or what Gibson calls *the education of attention* – takes place within the contexts of a perceiver's direct and practical engagement with his/her surroundings. From Gibson's work, two related concepts have been imported into HCI: *ecological constraints* and *affordances*. Of the two, *affordance* is by far the better known in HCI. The concept of *affordance* has, via Norman (1988), been widely adopted, used and misused (see e.g. Norman 2004a, 2004b). In HCI, affordance is used to refer to attributes of objects that allow people to know how to use them. *To afford* is taken to mean *to give a clue* as to how to interact

with something (Norman, 1988) (e.g. door handles afford pulling, cup handles afford grasping). A number of researchers, both within HCI and design, adapt this approach for the purpose of examining how people interact with artifacts. However, as pointed out by Robertson (1996), one of the differences between Gibson and Merleau-Ponty is that Merleau-Ponty focuses on all the senses rather than just vision, as is the case in Gibson's work.

Merleau-Ponty's work is used extensively in this thesis. Hence, in my choice of a theoretical foundation, I align myself with other phenomenologically motivated researchers in HCI, such as Robertson (1996, 1997b, 2000 and 2002), Svanæs (2000 and 2001), Dourish (2001 and 2004), Hornecker (2005 and 2006), Hornecker and Buur (2006) and Herstad (2007). These researchers, whose work I discuss in the next section, all emphasise the recognition of human embodiment as a starting point for conceptualising the relationships between human activity and technology design and use.

2.1.2 Embodiment in the Study of Human Action in HCI

An embodied approach to human perception and cognition takes the body with its perceptual and motor capacities as a starting point. In HCI, embodied approaches provide alternatives to cognitivist models of human cognition. Below I describe some work of other phenomenologically motivated researchers in HCI, as well as Suchman's (1987 and 2007) writing on *situated action*. Suchman's work is not described as phenomenological per se; however she works within ethnomethodology, which was influenced by both phenomenology and pragmatism, and the embodied nature of human action is fundamental to her research.

The work of Robertson (1996, 1997a, 1997b, 2000 and 2002) comprehensively describes the implications for HCI of a phenomenological perspective informed by Merleau-Ponty. Since then, Svanæs (2000 and 2001) and Dourish (2001 and 2004) have also filtered insights from phenomenology to make them relevant and useful to technology designers. In a field study of cooperative design in a multimedia company, Robertson draws on the phenomenology of Merleau-Ponty to develop a taxonomy of embodied actions that serve communicative functions in cooperative design work (1996, 1997a and 2000). She also relies on Merleau-Ponty's phenomenology to

emphasize the importance of the public availability of actions and artefacts for maintaining awareness in distributed activities (1996 and 2002).

Svanæs also promotes the application of the phenomenology of Merleau-Ponty to the study of design and use of technology. He uses phenomenology as one of two perspectives in a study that explores the concept of interactivity (2000). In the same work, he develops a prototype design in which he aims to address kinaesthetic aspects of technology interactions explicitly, and the importance of rediscovering what he calls the *lost* feel dimension. Svanæs also examines Merleau-Ponty's work in relation to the design of context-aware technology (2001), noting that phenomenology's first-person focus on the lived body and its relationship to the environment enables understanding of such systems from the user's perspective. His analysis recognises that context must always be understood from the perspective of those whose context it is.

In his book, *Where the Action is: the Foundations of Embodied Interaction* (2001), Dourish draws mainly on the writings of Heidegger, Schutz and Wittgenstein, and to a lesser extent on Merleau-Ponty. Dourish proposes embodiment as a basis for how to approach social and tangible computing as social practice, combining insights from phenomenology with ethnomethodology. These two influences are also present in his work on reinterpreting and defining context for ubiquitous computing (2004).

Suchman's (1987) emphasis on the situatedness of action is influential in HCI as it helps in contextualising the interaction between people and technology. Suchman maintains that human action is *fundamentally concrete and embodied* (1987, p. viii) and that it is situated and social in response to the physical and social environment. The relevance for my research is that when studying movement enabling interaction with technology, the meaning of movement as actions in interaction with technology must be understood from within the context of which the action takes place.

The fact of human embodiment as a starting point for the study of design and use is shared by a number of other researchers in HCI and related fields. Hornecker and Buur (2006, p. 439) propose *embodied facilitation, ...how the configuration of material objects and space affects and directs emerging group behaviour...*, as a major theme in their framework for the design of collaboratively used tangible

interaction systems. Hornecker and Buur recognise that any technology offers structure that implicitly directs user behaviour by making some actions easier, while constraining others. In tangible interaction systems, structure is as much in the physical actions that users perform as it is in the software itself (see also Robertson 2006). McCarthy and Wright (2004 and 2005) use the ideas of pragmatist philosophers John Dewey and Mikhail Bakhtin to explore what they call the *felt experience* of interaction with technology. They say felt experience is the aesthetic, sensual and emotional aspects of the meaning surrounding technological artifacts and our experience of them. Fallman (2003a and 2003b) argues for the importance of embodiment as a "design ideal" particularly when dealing with mobile interaction. In their paper, *How Bodies Matter*, Klemmer, Hartmann and Takayama (2006) provide suggestions for designers, for both generating and evaluating ideas and systems based around human embodiment. Using Heidegger's phenomenology, Herstad (2007) studies the notion of *visibility* as an aspect of use; discussing how during use, artefacts can become visible in different ways. Vaughan (2006) uses a phenomenological approach, exploring the concept of *inhabiting design* as the lived relationship between artefact, user and the lived experience of design. Common for these researchers and designers are that they use phenomenology and human embodiment as a way to approach or conceptualise the study of technology, and they are influenced or inspired by phenomenological sensibilities as a basis for developing design concepts.

2.1.3 Section Summary

Robertson and Svanæs are the two researchers in HCI who have most extensively used Merleau-Ponty's work. From their insights, I draw an understanding of the fundamental role our body plays in action and perception, in shaping our experiences and engagement in the world, our understandings of the world, and interactions in the world. An embodied approach advocates that meaning is to be found in the relationship between our bodies and the world in which we act, rather than in abstract concepts and ideas or by a mind governing a subordinate body. Every perception is an *interactive experience*, or as Merleau-Ponty puts it, a *communion* with the world (1962). Perception requires action; without action there is no experience of anything "external" to the subject. As he said, an active, perceiving body is our means to engagement with the world. Svanæs provides an example to illustrate and experience this point.

Physical Exploration 2.1: The importance of action in perception

> Pick up a pen. Keep the cap on, and hold it as you do when you are writing. Touch the tabletop or something else in your environment with the pen, and sense the form and texture of your immediate environment through the pen. Close your eyes, and concentrate on how you perceive the world. Block out as many other senses as you can. (Svanæs 2000, p. 218).

I take this understanding of the body's role in perception into an exploration of movements as actions enabling interaction with technology. However, Suchman's notion of *situated action* also requires consideration of the contingencies of action, the situated and contextual aspects of the movements performed to enable interaction.

My work is indebted to all the researchers above for the ways in which their work has opened up considerations of movement and everyday experience in HCI research. In the next section, I want to further develop a sense of the *experience of moving* in technology interactions. This experience of moving is part of our sense-making in relation to technology, yet this aspect of our interaction experience seems underplayed in accounts of movement enabled interaction and user experience, both in studies of design and use.

2.2 Understandings of Human Movement and Experience

In the previous section, I looked to philosophy for an understanding of the role of the body in perception and action. In the following, I look to disciplines such as anatomy, anthropology, choreography, dance, movement studies, sociology, somatic practice, computer vision and computerised recognition and analysis of human movement, for ways to study and understand movement and movement experiences in relation to technology. These different disciplines have differing models and approaches to understanding and representing human movement and experience. Underlying the different approaches are philosophical foundations and assumptions that inform the way human movement is conceptualised, studied and explored.

From Suchman (1987), Kendon (1990) and Robertson (1996, 1997b and 2002) among others, we learn about the communicative potential of movement. When considering movement in interaction with technology, we have to address movement as communication at this level. The body and its movements, as the foundation for communication and social relations, are continuously "read" and interpreted by others.

We influence others through our corporality and we are also influenced by others' corporality. The meaning of a movement must be understood in its social and cultural context. For example, Williams (2004) discussed the differences between the *space internal to the rite of a Mass* and that *internal to a football game*. During Mass in a Christian church, a priest performs a pattern of codified movement that has specific meaning for the ritual of the Mass. Ritual movements tend to emphasise the rhythmic and symbolic aspects of movement, these movements are understood by those who attend Mass. In comparison, a football player performs a series of set moves as well but in a much more improvised fashion, according to the contingent action of the game.

Similarly, social and cultural context will influence the movements we might be willing to perform in relation to technology in different contexts. Hence, the way movements take on meaning in different settings, and the way a setting determines the meaning of movement need to be considered for interaction design. Within this frame, I focus here on three different ways of approaching the understanding of movement and experience: movement as *object*, as *subjective* and as *knowing*:

- Understanding movement as an object, means approaching movement as an object for investigation (e.g. the arm moved), as means to some end (e.g. press a button) or as an object for others or yourself (e.g. pulling my mobile phone out of my pocket I become conscious of being observed);
- Understanding movement and experience as subjective is to approach the body-subject's awareness and meaning of movement, and as an intuitive experience of bodily existence as being-in-the world, (e.g. the feeling and experience of a yoga pose or my movements when playing Nintendo Wii™); and
- Understanding movement as a form of knowing means to consider the mutual constitution of knowing and doing involved in the performance of bodily skill, (e.g. correctly inserting the ink cartridge into the printer or handling equipment in a chemistry lab).

I shall discuss the three perspectives in depth in sections 2.2.2, 2.2.3 and 2.2.4 respectively, but first I present some activities that the reader may choose to carry out for additional engagement with these perspectives.

2.2.1 Activities for Understanding Movement and Experience

In this section, I provide some activities that the reader might choose to read through or alternatively engage with by carrying out the activities. The activities are provided as a different way to approach the three proposed understandings of human movement and experience: as an *object* for investigation, as *subjective experience* and as a form of *knowing*. The activities can be carried out alone or by two people working together: one person moving and the other observing, then reflecting on and discussing the experiences. I shall intermittently refer back to these examples in later sections. Immediately following the examples, I describe how each example illustrates the different understandings of human movement and experience.

Physical Exploration 2.2: Activities illustrating different understandings of human movement and experience

I. You are "cruising along" walking (or running, swimming, paddling, biking). Your movements feel smooth, you no longer have to focus on your movements and the experience is one of effortlessness.
II. You raise your arm to shake out tiredness.
III. You are walking barefoot on hot sand, tiptoeing as quickly as possible to a cooler spot.
IV. You wave to your friend.
V. You are walking along and you become aware of being watched, or you see yourself reflected in a window. You become aware of or even self conscious in your movements.
VI. You are walking on ice or down a muddy slope with a heavy bag on one shoulder. You do not want to slip!
VII. Carry out one task you are very familiar with and one you are not familiar with at all. Do not tell the observer in advance which is which.

The examples illustrate that we can experience and understand movement in many different ways. In the first example, the mover has found the rhythm. The body and focus have become one. The mover might or might not be paying attention to the movements or to the integrated experience of effortlessness in the activity. The movements in examples II, III and IV are all reflexes in response to the sensation in

the mover's arm, physical and social environment; the mover is not really paying attention to her or his movements, but to the arm, toes and the friend. In the fifth example, the mover becomes aware of and even self-conscious in the movements. The mover might appraise her/his clothes and posture based on social norms for a particular look and movement in a setting. Walking on ice, or down the muddy slope, in the sixth example, the mover is probably focused on not slipping, and the observer might see how the bag (an extension, a wearable to the body) affects the movements. In the seventh example, the movements are probably hesitant and awkward when carrying out the unfamiliar task, and smooth and confident when carrying out the familiar task. It is easy for the observer to tell which is the familiar task, even if the observer is not skilled in the task.

The examples show the difference between being a mover and being an observer as well as the context for understanding movement. At the same time as the activities illustrate different ways of approaching the understanding of movement, they also illustrate *perspectives*.

The first example emphasises the kinaesthetic and proprioceptive aspects of movement for the actor. It demonstrates how movements can be described from the perspective of the experience of the moving body. The other examples illustrate descriptions of movement of anatomical, functional, communicative and social natures. In example IV, when the mover waves to the friend, the friend (or the partner observing) will probably interpret this as a greeting. But a computer would interpret it simply as "the arm went up" or possibly even more simply as something tracing a path in space or intersecting with a sensor in a certain space and time. Example V describes the fact that an external observer has an impact on the situation; being observed can elicit a range of reactions from embarrassment to excitement, depending on the person and the setting. In example VII, the flair and expressiveness of the movements will reveal whether the person is skilled or not. There is the subjective experience of being skilled, for example, movements carried out while playing an instrument or handling a tool are part of the subjective experience of mastering the instrument or tool, but these movements are also observable as part of the performance of handling the artifact.

The Possibilities of Different Perspectives

Considerations about the kinds of understandings of human movement and experience that can provide useful perspectives for interaction design, are issues of both methodological and epistemological significance. I argue that in order to inform the study and design of technology that relies on movements of the body for interaction, we need perspectives and methods that allow us to study movement with appropriate analytical rigour, utilising perspectives that incorporate both the experiences of being a mover, experiences of observing other moving bodies, and opportunities to reflect on both perspectives. Understandings about first-person or subjective experiences of movement can give us insights into the relationships between movement and experiences in life. Objective understandings explain movement from an external perspective and are concerned with different aspects of how movements are perceived from a third-person point of view. This perspective can give us understandings of how technology "understands" human movement, how to use the body efficiently in work, how to avoid injury and so on. Understanding movement as a form of knowing addresses the connections between perception and skill. In studying and developing understandings of movement for interaction design, we deal with movement as both a tool and material for design. I further discuss the possibilities of multiple perspectives in section 3.6.2.

2.2.2 Movement as Object

Where the *body subject* studied in phenomenology refers to the basic, intuitive experience of bodily existence as being-in-the world (e.g. the first activity in Physical Exploration 2.2 above), in other areas of study it is more common to treat movement as an object for investigation, as means to some end or as an object for others or yourself, for examples as described in the previous cited examples.

The body as muscles, bones, angles of displacement, locomotor patterns or positional behaviours is the body studied in both biomechanics and gesture recognition. Movement is understood from the point of view of physiology, anatomy and the goal of movement is transport. If we click a mouse, the movement can be measured and calculated. This is the type of understanding used in much sensing by technology. Movement is seen as a *means* to an end rather than a fundamental part of human experience. This view is useful for HCI as it provides both constraints and resources in the determination of possible movement profiles for movement-based interaction

with technology. The area of human factors engineering also takes this view of movement with its focus on the ergonomic relationship between people and technology.

Motor activity has been formalised, through dance notation and in movement practices such as tai chi and yoga. The first system for dance notation dates back to the late 1500s (Arbeau 1589). Systems for dance notation currently in use include: Benesh - a system for ballet based on an abstract stick figure representation on a music stave; Eshkol-Wachmann - a more general system, not specifically tailored to the human form, and Labanotation (Hutchinson 1977). Labanotation is a system of analysing and recording movement, originally devised by Rudolf Laban in the 1920s and further developed by Hutchinson and others at the Dance Notation Bureau, New York (Hutchinson 1977). It continues to be used in fields traditionally associated with the physical body, such as dance choreography, physical therapy and drama. It has also been applied in anthropology and industrial production. It can be used for analysis and choreography of all forms of human movement. Labanotation is covered more extensively in my first study in Chapter 4.

Other work in HCI using Labanotion and Laban's theories of movement falls into two main categories – simulation and recognition. Badler and Smoliar (1979) used Labanotation for some of the most extensive and early work on simulating movement as part of computer animation. This has been continued with the development of the EMOTE model – a 3D character animation system that incorporates other elements of Laban's theory in order to produce simulated movement that is more natural and expressive (Chi et al. 2000). Further examples include animation systems for visualising dance choreography from written notation scores, such as Life Forms, NUDES and Virtual Ballet Dancer (Neagle et al. 2003). Aspects of Laban's theory are also being used in attempts to extract emotive qualities from human movement – as part of computerised motion recognition systems such as EyesWeb, a system that recognises gesture and affect from dance movement (Camurri et al. 2000 and Camurri et al. 2003); the design of gestures for affective input (Fagerberg et al. 2002); and the gestural semantics of caress (Schiphorst and Fels 2001). Most of this work focuses on the representation of human or human-like movement within the computer.

Another early form of movement analysis was developed by Muybridge (1984) in the 1890s. It involved the use of sequences of photographic stills. He created a large archive of photographic documentation of what he called human locomotion - sequences of split-second images of people performing actions ranging from stooping for a cup to dancing and dressing. See two different illustrations of the sequences of a headspring in Figure 2.1 below.

[Production Note: This figure is not included in this digital copy due to copyright restrictions.]

<click here to view>

Figure 2.1: Still images of a headspring, photographed by Muybridge

His work was the forerunner for contemporary methods of movement analysis dominated by use of the video camera (Farnell 1999) and computerised motion analysis (Aggarwal and Cai 1999). This technique of presenting a sequence of stills to represent a phrase of movement is being used today within the fields of human-computer interaction and game design. Some researchers have found video-based analysis and representation of human movement to be more efficacious for game design than graphical notation systems such as Labanotation (e.g. Höysniemi and Hämäläinen 2004). Contemporary movement analysis is also the domain of biomechanics, sports science, sports performance and physical rehabilitation. These fields typically use computerised motion analysis systems that are based on a biomechanical understanding of the moving body.

Summary: The objective perspective is important as it is the abstraction that technology uses. I have discussed various representations of objective understandings of movement. In this thesis I draw on Laban's ideas and representations.

2.2.3 Movement as Subjective Experience

The body studied in biomechanics or as proposed by Laban treats movement as an object for investigation (e.g. the arm moved), as means to some end (e.g. pressing a button on a mouse) or as an object for others or oneself (e.g. pulling my mobile phone out of my pocket, I become conscious of being observed), to use the earlier examples. On the other hand, the *body subject* studied in phenomenology refers to the basic, intuitive experience of bodily existence as being-in-the world, as illustrated in the first activity in section 2.2.1.

According to Merleau-Ponty's phenomenology (1962), our bodies play a fundamental role in shaping human experience in the world, understanding of the world and our interactions in the world. We can only perceive and act in the world through our bodies, and we experience the world in all the ways in which we perceive it. The world is inherently meaningful for our body, and by moving, we can gain access to that meaning. In this section, I first discuss how I understand the body's role in perception, providing ideas and concepts necessary for me to conceptualise the relationship between bodies and technology (or things):

> *If the senses are the means by which we experience the world, then any theory of the senses assumes a theory of perception by means of which such experience is possible.* (Farnell 2003, p. 133)

In our interactions in the world, we use all our senses, we see through the eyes; we hear through the ears; we move our fingers across a surface to know its texture; we experience the position and movement of our arm through our kinaesthetic and proprioceptive senses, and so on. As we have separate inlets for the different senses, the senses are not interchangeable. However, they are interrelated and provide unified aspects of our bodily engagement with the world (Merleau-Ponty 1962). So, when I suggest studying the specificity of the kinaesthetic and proprioceptive senses, I do not intend to reduce human interaction with technology to sense perceptions from these senses. The kinaesthetic and proprioceptive senses would not be isolated in lived experience. Our different senses make available the worlds in which we can act, but they are not reducible to each other. Each sense immerses our bodies in our worlds in

different ways. My intention is to look at the specificity of the kinaesthetic and proprioceptive senses, because these senses provide different experiences in relation to technology than, for example, the much better understood visual dimension. We need to understand kinaesthetic and proprioceptive experience in relation to technology in order to inform the study and design of technology that relies on movements of the body for interaction.

I now describe different aspects of perception through movement, particularly with reference to how we perceive our physical selves in space and how we perceive when acting through things. This provides ideas and concepts necessary for me to later conceptualise the relationship between bodies and technology (or things).

The Kinaesthetic and Proprioceptive Senses

Using our kinaesthetic sense and proprioception, we locate the position of body parts in motion. This can be regarded as a process of *locating ourselves from inside* (Berthoz 2000). This is an ongoing process while we carry out other activities. Laban, talks about the kinaesthetic sense this way:

> *...the sense by which we perceive muscular effort, movement, and position in space. Its organs are not situated in any one particular part of the body, as those of seeing and hearing, ..., but they are nerve endings embedded in muscular fibres all over the body.* (Laban 1988, p. 111)

Gallagher (2005) said that bodily impulses and perceptions from inside are important for a person's sense of self. Damasio (2000) even suggested that a large part of what allows us to feel like the same person from day to day is the sameness of these signals from the body day after day; *somatic markers* tell me that I am still *me*. *We are not all endowed with an equally fine kinaesthetic sense...*, Laban wrote (1988, p. 111). However, the kinaesthetic and proprioceptive senses can be cultivated to gain an increased appreciation and awareness of it.

Touch and Haptic Perception

Touch is considered one of the five senses. However when we touch something, it gives rise to various feelings such as the perception of pressure (shape, softness, texture, vibration, etc.), relative temperature or sometimes pain. In everyday speech, we use the term *touch* to cover all of these. Gibson identified two forms of haptic perception, *active* and *passive* touch (1962). Active touch corresponds to what most people call touching, that is what occurs when people move their fingers and hands to

explore properties of an object. Passive touch does not involve movement of hands and fingers; stimuli are simply pressed into the skin. (See e.g. Carello and Turvey's (2000) account for more on the dynamics of touch). The difference might be experienced by trying the example below.

Physical Exploration 2.3: Experiencing passive and active touch

> Close your eyes and have another person press an object into your hand, try to identify what it is.
>
> Still with your eyes closed, try this again, this time use your hands to explore the object.

Although we can perceive some information from the weight, and maybe the temperature of the object placed in our hand; active touch, that is being allowed to explore the object, makes it easier to identify the object.

In HCI, we often refer to *tangibles* to describe interactions where a digital object (other than a keyboard and a mouse) is manipulated using the hands, and *haptics* to describe technology engaging the sense of touch by exerting pressure or vibration to provide feedback and output. Harrison et al.'s (1998) explorations of direct manipulation and physical affordance of user interfaces, game controllers (e.g. the Nintendo® Wii™ 2006), *tactons*-vibration alerts on mobile phones (Brown and Kaaresoja 2006) are examples of haptic technology. While Brereton et al.'s work on supporting dentistry practice (e.g. Campbell et al. 2003 and Cederman-Haysom and Brereton 2006) is an example of a tangible interaction.

Spatial Perception and the Body as Our Point of Reference when Moving

> *The word 'here' applied to my body does not refer to a determined position in relation to other positions or to external coordinates, but the laying down of the first co-ordinates, the anchoring of the active body in an object, the situation of the body in face of its task.* (Merleau-Ponty 1962, p. 115)

Our actions unfold in space, using our kinaesthetic and proprioceptive senses, our sense of touch and our other senses. We locate ourselves in space and orient ourselves to the world around us (and objects in it), with our bodies as our point of reference. We construct the spatial relationships we perceive, using our spatial perception. We are aware of our bodies as an object among other bodies and objects. When we reach down to scratch a knee, we act within the spatiality given by our bodies. When we

reach over to press the *on* button on our laptop we act within a space given by the relationship between our bodies and the action we want to perform, that is, turn on the laptop. As expressed by Merleau-Ponty, our spatial perception is constituted by our potential for action in the world:

> *Brought down to a precise sense, this term means that my body appears to me as an attitude directed towards a certain existing or possible task. And indeed its spatiality is not, like that of external objects or like that of 'spatial sensations', a* spatiality of position, *but a* spatiality of situation. (Merleau-Ponty 1962, p. 114-115, emphasis in the original)

Merleau-Ponty goes on to argue that *bodily space can be distinguished from external space* (ibid, p. 115). While external space is organized along the axes up-down, left-right, and front-back, bodily space is constituted by a person's potential for action in the world. Our bodies are our *point of reference* when moving in space. In *The Visible and Invisible,* Merleau-Ponty (1968) provides the concept of *reversibility*, described by Robertson as

> *...reversibility provides a name for the complex intertwining between the perceiver, the perceived and the physical environment that is the essential condition for our interaction with the world and with others.* (Robertson 2002, p. 304)

When considering subjective experience of moving, the idea of a *point* or *frame of reference* is tied to that of space. In his book, *The Brain's Sense of Movement* (2000), Berthoz talks about *frames of reference* and refers to studies in neuroscience that suggest we divide the spaces used to organise our perception and action into *personal* space, *extra personal* space and *far* space (p. 98). *Personal* space is perceived by the internal senses to be within the limits of one's body. It is however important to note that one's own body can be perceived as an external object, for example by vision. This is fundamental to Merleau-Ponty's (1968) concept of reversibility. In *extra personal* space, an object is perceived where it is supposed to be and not at the point of contact of the instrument or object with the body. Extra personal spaces are within our grasping reach. Then there is *far* space which is out of reach. In this space, for example, the gaze of others and music might impact our movements. Berthoz provides some entertaining and enlightening activities to explore these concepts. (See p. 228 in his book, *The Brain's Sense of Movement*).

Perception when Using Things (Tools)

The perception of these spaces has links to our perceptions when using tools. As described by extra personal space, tools extend our potential for action: a tennis racket

becomes an extension of the hand, and a car becomes incorporated into our bodily space. In skilled handling of a tool, we are absorbed in our activity and the tool exists for us as part of the activity. However, if something changes or the activity is interrupted, for example, we hit the tennis ball off centre in a serve; our focus reverts back to dealing with the tool rather than being fully engaged in our activity. In conceptualising the relationship between bodies and things (and bodies and technology), we refer to the familiar image of how the blind man's stick becomes an extension of the lived body, an extension of self (Merleau-Ponty 1962, p. 165). Merleau-Ponty explains how the world perceived does not begin at the point where the hand holds the stick, but at the end of the stick.

> *The blind man's stick has ceased to be an object for him, and is no longer perceived for itself; its point has become an area of sensitivity, extending the scope and active radius of touch, and providing a parallel to sight. In the exploration of things, the length of the stick does not enter expressively as a middle term: the blind man is rather aware of it through the position of objects than of the position of objects through it.* (Merleau-Ponty 1962, pp.165-166)

Heidegger's hammer is also frequently cited to theorise how we use tools, in his example of distinguishing the hammer from nailing as, *present-at-hand* and *ready-to-hand*, respectively (1962). Through skilled use, a hammer becomes transparent; it is ready-to-hand, part of the given situation of the act of nailing, an extension of the lived body. If the hammer breaks or stops working, it becomes an object in the world again: present-at-hand. The world reappears in the form of objects with their potential for use (ibid). In both these examples, the lived experience is that of the body and thing as a moving couple; we are inattentive to the properties of the thing and absorbed in the activity of say, walking or nailing as long as everything is working well.

In addition to Winograd and Flores' (1986) work where they adopted Heidegger's (1962) *present-at-hand* and *ready-to-hand*, the seminal works of both Suchman (1987) and Bødker (1991) contain early interpretations of the notion of *breakdowns* in HCI. Both Suchman and Bødker characterise successful interaction in terms of the absence of breakdowns in communication between people and technology. Using the term *conceptualisations*, Bødker refers to breakdowns in a manner similar to Heidegger's explanation; it involves the tools becoming objects in the world again as well as a conceptualisation of the operations involved. When I, in this thesis, discuss kinaesthetic and proprioceptive experiences in interaction with technology, I refer to

breakdowns or the absence of breakdown in communication as perceived by, or through, the kinaesthetic and proprioceptive senses.

Body schema

Above, I have outlined how I understand the body's role and tools in perception, particularly with reference to how we perceive our physical selves in space and how we perceive when acting through things. The different senses are interrelated aspects of our bodily engagement and experiences in the world. Merleau-Ponty (1962) provides the *body schema* as a unifying agent by which we organize perception and action:

> *Now just as within each sense, we must find the natural unity which it offers, we shall reveal a 'primary layer' of sense experience which precedes its division among the separate senses.* (ibid, p. 264)

The body schema is to be understood as a background to our capacity to organise our bodily movements. It is a dynamic phenomenon, not just a sensory image. The acquisition of *habit* can be seen as a *rearrangement and renewal of the corporeal schema* (ibid, p. 164), which is continuously modified by our movements and activities. Perception and motor skills are in constant dialogue, and the organisation of our movement patterns for perception depends upon our habits of perception.

I draw on these approaches in trying to access subjective experience of movement in this thesis. By also considering movement in the light of somatic practices and as investigative and exploratory practice, I extend methods currently available in HCI, and it enables me to discuss bodily knowing as a form of knowing.

Summary: In this section I summarise subjective experiences of movement. This perspective is important for this thesis as it is the perspective I claim is lacking in HCI theory and literature in order for us to gain a good understanding of kinaesthetic and proprioceptive experiences with technology. It is also the perspective from which I generate my contribution as a participant-observer. (I detail the methodological aspects of this in section 3.6). I have described how I understand the role of proprioception and the kinaesthetic sense in perception, as well as the body schema as a way of organising our perception and action. This helps bring us to an understanding of our knowing how to do a movement.

2.2.4 Movement as Knowing[2] and Understanding

Mastering different forms of movement in different settings is part of the skills we can learn and acquire as we mature. We know how to move and behave in certain settings; this is deeply ingrained in us as knowing how to move at all. Returning to the examples in Physical Exploration 2.2 at the beginning of section 2.2.1, when observing a person skilled at what they are doing, it is easy to tell whether that person is skilled or not, regardless of the observer's familiarity with the activity. The ease, fluency and confidence, or alternatively the jerkiness and insecurity, of the performance would reveal whether a person is skilled in the activity.

Learned skill or *habit* as Merleau-Ponty (1962) called it, is about our constant process of embodied meaning making with our surroundings. This engagement with the world develops our capacities of action and perception in the activities in which we engage. Merleau-Ponty said, *habit* is *...the coming into the possession of a world* (ibid, p. 176), a world in which we understand how to act:

> *The acquisition of a habit is indeed the grasping of a significance, but it is the motor grasping of a motor significance* (ibid, p. 165)

The *motor significance* Merleau-Ponty describes in relation to the *acquisition of habit* illustrates that it is through our bodies and with our movements we understand when we finally grasp or master a skill, such as playing an instrument, using a computer mouse, a new dance and so on. Merleau-Ponty linked the *acquisition of habit* to *a rearrangement and renewal of the corporeal schema* (ibid, p. 164). Our perception and the *corporeal schema* or *body schema* is, as I described in the previous section, the means by which we organise the world around us.

Our movement in knowing how to do something is not divorced from action, but is a constitutive part of it, and it involves more than just knowing what should be done; it involves knowing what should be done consistently and under different circumstances. From this perspective, movement can be understood to be *knowing how* to do an activity, that is, the knowing is performed in the doing of the activity. Polanyi (1983) articulated the distinction between *knowing how* and *knowing that* from his concept of *tacit knowing*:

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[2] I have chosen to use the term 'knowing' rather than 'knowledge' to give emphasis to an understanding of knowing as a process, i.e. as our capacity to respond to situations, in addition to knowing as generalisable knowledge that can be made explicit.

> *...explicit integration cannot replace its tacit counterpart. The skill of a driver cannot be replaced by thorough schooling in the theory of the motorcar; the knowledge I have of my own body differs altogether from the knowledge of its physiology; and the rules of rhyming and prosody do not tell me what a poem told me, without any knowledge of its rules.* (Polyani, 1983, p.143)

Learning to ride a bicycle, to tie one's shoes or to drive a car are often quoted as examples of *knowing how* as opposed to *knowing that* a bicycle rolls, that shoe laces can be tied or that a car needs fuel. In order to learn to ride, a person must practise riding, and over time, the skill of riding a bike becomes second nature; it can be accomplished with minimal attention to the movements involved, on different bikes and on different terrain. *Knowing how* is learned only by experiencing activities.

Craft as a form of Knowing through Moving

Both *knowing how* and *tacit knowing* are integral to the making in *craft*. The term is often used in relation to the making of physical and three-dimensional artefacts, for example, woodwork, pottery or sewing. Skills related to *crafts* rely on the mutual constitution of knowing and doing, that is knowing what needs to be done under different circumstances. The skills needed to be good at a craft incorporate all our senses: touch, sight, hearing, smell and the kinaesthetic and proprioceptive senses. Drawing on Godal's (1997) characterisation of "activity-based" or "activity-carried knowing"[3], a person skilled at a craft can be characterised as having:

- A good understanding of the properties of materials, where the material may be physical or digital;
- An intimate understanding of the tools available and their capacities;
- A feeling for the rhythm of the interaction with the tools, including the movements for good grips, positions and patterns in the activity; and
- An understanding of the steering movements for coordination of balance and dexterity, for example, the sound and smell of the right piece of wood for a particular part of a boat, or the right programming language for motion detection for different sensors.

The concept of craft points to understandings and abilities to respond to situations with the whole body in combining skills, knowing and intuition. A person skilled in their craft is also a critic or a connoisseur[4]. The term *connoisseur* is often used about

[3] Translated from the Norwegian term "handlingsbåren kunnskap".
[4] Connoisseur comes from Latin *cognoscente*, which means 'to know'.

the *art of appreciation*. It involves the ability to see and recognise, not merely to look. To do this, one has to develop the ability to name and appreciate the different dimensions of situations and experiences, and the way they relate one to another, and further enable others to see the qualities of something. Craft is about skilful coping or skilful interaction with some part of the environment.

The tacit knowing and *knowing how* of craft skills could equally be used to describe the type of skills involved in and exhibited using equipment in a chemistry lab (e.g. Goodwin 1997), those performed by nurses (Waters and Cashin 2003) or by interaction designers (Wroblewski 1991). Based on considerations of interaction design as a craft, Wroblewski suggested back in 1991 that interaction design needs more appropriate tools, more responsive materials, articulate craftsmanship and craft-methodology. He also raised the question of what research or the construction of knowledge could be like if the construction of human-computer interfaces were considered as a craft. Since Wroblewski, craft has made sporadic appearances in HCI, for example, McCullough (1996), Bacigalupi (1998), Jensen et al. 2005, Jensen 2007 and Löwgren (2008).

Schön's theories of reflection

As suggested by Schön (e.g. 1983, 1987), for practitioners in many spheres, knowing, doing, feeling and making sense are inseparable. Within the realm of professional practice, Schön (1983) examined the practice of five professions (engineering, architecture, management, psychotherapy and town planning), arguing that the skilful practice exhibited by professionals does not consist of applying some a priori knowledge to a specific decision or action, but rather of a kind of knowing that is inherent in their action. He said, *Although we often cannot say what it is we know, we do know how to take action,* (Schön in Winograd et al. 1996, pp. 172-173). For Schön, the exhibition of skill or artistry as a professional is an exercise of intelligence, a kind of knowing in action. Dearden (2006) discussed Schön's concept of *design as a conversation with materials* within the context of HCI. Although, Dearden does not take his discussion into an embodied realm, he proposes that *...the material properties of digital systems and the genres of practice that surround their use* (p. 399), provide a good source of insights to inform the development of tools for digital design.

Schön (1987) identifies two types of reflection; *reflection-in-action* (thinking on your feet) and *reflection-on-action* (retrospective thinking). He suggests that reflection is used by practitioners when they encounter situations that are unique and to which they may not be able to apply theories or techniques learned previously.

Judging by the number of publications citing Schön, the design approach that he argues for and the concepts that he introduced have been influential among HCI and interaction design practitioners. Schön managed to find a way to describe design practice that can be recognized by practising designers, as well as providing concepts that can be used as intellectual tools in the planning and development of the design process. He did this without prescribing the process on any detailed level.

Summary: In this section I outlined a third way of approaching the understanding of movement and experience: movement as knowing and understanding. This perspective is about skilled movement and mastering different forms of movement in different settings, this could be movements required as part of nursing practice, woodwork, craft making or interaction design. The relevance of this perspective is that movement as craft, and the mutual constitution of knowing and doing will be applied in trying to understand movement as a material for interaction design, movement as a craft and the nature of movement practice. To this end, Schön's theories of reflection become important. In this research, I draw on both *reflection-in-action* and *reflection-on-action* in exploring *bodily reflection*.

2.2.5 Section Summary

The activities provided in section 2.2.1 describe movement as an *object* for investigation, as *subjective experience* and as a form of *knowing*. Each activity can be used to highlight distinct, but related ways of understanding movements *as objective (and means): as subjective experience*; and *as understanding and knowing*. Focusing on the objective perspective, we are concerned with how the movements look or are experienced from a third-person point of view. Highlighting the subjective experience is concerned with experience from a first-person perspective, while movement as knowing and understanding can be used to describe movement both from the point of view of the person moving as well as an observer. The different approaches have consequences of epistemological character. The way to perceive understandings about

my own movement is a different kinaesthetic and proprioceptive experience than my knowledge that you are in movement.

The different perspectives on movement elaborated in sections 2.2.2 - 2.2.4, disclose different aspects of movement and allow for a multifaceted view of movement in technology interactions. The perspectives also provide different approaches to the study of movement, and hence insights into the relationships between movement, interaction and experiences in technology interactions. From the different understandings of movement outlined above, I now draw on both the subjective experience of movement and parts of Labanotation (section 2.2.2 and Chapter 4) when I discuss subjective experiences, descriptions and representations of movement in relation to technology interactions.

2.3 Movement, Experience and Technology

As a consequence of the way I see movement as integral to human existence, all technology interactions not only involve movement, but require movement.

Inspired by claims that increased physicality enriches the user experience in tangible and augmented environments (e.g. Camarata et al. 2002, Schnadelbach et al. 2002), the *move beyond the desktop* has been hailed as promising "new" interactions that would allow people to interact in ways that fit more naturally with the way we are accustomed to moving our bodies in the physical world. These "new" interactions are indeed driven by the physical makeup of the human body and also by the ways in which the body is involved in meaningful actions in a physical and social world. However, it is only partially true that the new interactions allow us to transfer our abilities from the physical world to interactions in hybrid and virtual environments. Also, little knowledge has been established, so far, as to why increased physicality in relation to technology would produce such effects.

The most common way movement is currently "used" in interaction with technology is in terms of its "presence" or "absence". In most interactions, the interaction is dependent on the *moment of interaction*, for example, the finger hitting the spacebar on the keyboard, the hand because it is holding the mobile phone to the ear and so on. The finger *on the way to* hitting a key on a keyboard is neither observed nor significant (from the point of view of technology). The key can be pressed in

excitement or frustration; either easily noted by an observer, but both irrelevant to the technology. All that matters is which key was pushed when. Movement is seen as a *means* to an end rather than a fundamental part of human experience. For the person carrying out the interaction *...a moment of interaction is actually embedded in an entire gesture that determines its timing and feel...* (Benford et al. 2005, p. 12). Readers familiar with rackets or clubs in sports, tools in craft making or the playing of an instrument will recognise this. Movements for interaction consist of preparation, the moment of "impact or interaction" and follow through after the point of interaction.

2.3.1 Movement as Object for Investigation in Interaction Design

Currently, most interactions that are enabled through movement *away from or beyond the desktop* rely on this *moment of interaction*. They combine the use of changing visual cues (visual output) with some form of a tangible element or a device (buttons on a control panel or a touchscreen, a games controller, a foot pedal etc). Auditory and haptic feedback are used mainly as extensions of visual feedback and are less frequently used on their own; or they are researched as alternatives for people with visual impairments (e.g. Ryota et al. 1999, Tzovaras et al. 2004 and Winberg and Bowers 2004). There is an increasing number of interactions where people move "free to air". This means that the technology does not require that people touch anything, but the presence or movement of the body is tracked and captured with, for example, cameras. A cross between free to air and tangible interactions uses gloves or similar devices for input and interaction control. A visual interface of some form is still common in these interactions as it is a challenge to provide people with points of reference for their movements otherwise. Although many of the so-called "new" forms of interaction beyond the desktop allow interaction through different movements, they are really just new ways of pointing and clicking.

Several researchers have suggested categorisations for how movement is *used* to enable interaction. These categorisations range from focusing:

- Explicitly on the body or movements of the body in the interaction (e.g. Mine et al. 1997, Ängeslevä et al. 2003, Kim et al. 2004a, Kjölberg 2004, Matthews 2005, Larssen et al. 2004, Loke et al. 2005a and Loke at al. 2007);

- On tangible aspects of an interaction (e.g. Fishkin et al. 2000, Fishkin 2004, Jensen et al. 2005, Hornecker 2006 and Hornecker and Buur 2006 and Jensen 2007);

- On using movements for artistic expression or bodily perception (e.g. Krueger 1990, Schiphorst and Anderson 2004 and Schiphorst 2006 and Ip et al. 2002a, 2002b and 2003);

- On the space in which the interaction takes place (e.g. Ciolfi 2004, Bongers and Veer 2007 and Eriksson et al. 2007);

- On the sensors and movement of the technology and in so doing implicitly focusing only on the movements (e.g. Bellotti et al. 2002, Benford et al. 2005, Reeves et al. 2006, Rogers and Muller 2006) or

- A combination of the above ideas.

A few researchers have also discussed how interaction designers might address the aesthetics and perception of movement or motion in visual interfaces. For example, Harris et al. (2002) work on the perception of self-motion, Bacigalupi (1998) integrates dynamic movement with static images, and Vaughan (1997) proposes that understanding motion expression of performance art can be helpful in applying movement as a design element in interfaces. All these approaches are useful as they highlight different aspects of the interaction. The approaches focusing explicitly on movement and those using movement for artistic expression are the ones most relevant to my research.

Approaches that focus on movement

Research that focuses on movement usually relies on the body's capacity for movement. This is often achieved by concentrating on parts of the body as points of interaction, on movement of the body for interaction control, or using a combination of the body and physical space around the body as an interface. For example, *Charade* (Baudel and Beaudouin-Lafon 1993) is an early example of an interaction enabled through hand movements. With the use of a glove, the system could recognise sixteen different commands for controlling a Hypercard presentation (e.g. the next slide). Mine et al. (1997) propose a design framework based on utilisation of proprioception,

describing three forms of *body-relative* interaction techniques: using the body's senses to control technology; ways to store/recall information relative to the body; and using body-relative actions to issue commands. Kim et al. (2004a) suggest four types of *body-based interfaces:* body-inspired metaphor; body-as-interaction surface; mixed mode (mix of the previous two); and object mapping, spatially mapping an interaction object to the body. An expanding, but so far non-exhaustive list of movements being used for interaction is: wave a hand to activate, head nod to activate, touch to activate or confirm, toe-tap, shoulder shrug, raise eyebrow, shake to clear, tilt to move or scroll, tilt to change state, flip to silence and move whole body in a direction (see Interactive Gestures Library (online)).

Another "use" of movement in technology interaction, is exemplified by Chua et al.'s (2003) system, which facilitates Tai Chi training in a virtual reality (VR) environment. A wireless system tracks movements of the body and presents the student with different images of a virtual Tai Chi master and the student in a head-mounted display (HMD), for example, the master standing directly in front of the student, multiple copies of the master surrounding the student, superimposing the student over the virtual master and so on. Here the focus is not on the use of movement for explicit control of the system, but to learn and build a physical skill.

Approaches that use movement for artistic expression

In an interactive artwork, the presence of a body or *how* a person moves, the whole body or a part of the body, might be part of an artwork. The presence or movements of a body or bodies might be used to trigger or generate responses partially or fully defined by the artist. In these kinds of works, movements of the body in relation to the technology can be *used* to express or entertain one's self and others, in the experience of the interaction and the experience of the result. This kind of use of movement in technology interactions is seen in works such as Krueger's *Responsive* and *Videoplace* (1990); Schiphorst and Kozel's *whisper* (reported in Schiphorst and Anderson 2004) and Schiphorst's *exhale* (2006), *Body-Brush* by Ip et al. (2002a, 2002b and 2003), Khut's *Cardiomorphologies* (online) and Sheridan's *iPoi* (online and Sheridan et al. 2007).

Summary: My interest is in elements of movements, design representations of movement and experiences of movement enabling interaction. The above mentioned

frameworks and lists focus on the whole body or generalised movement of a body part in an interaction. They do not provide enough detail in terms of describing parts of the body, qualities of movement involved in the interaction and the kinaesthetic and proprioceptive experiences of the interaction. For my purposes here, I now try to complement the above mentioned works with the use of terminology from the *structural* form of Labanotation (Hutchinson 1977) to show how the elemental nature and more detailed descriptions of movement can be used as a complementary way of describing movement in relation to technology. I draw on both my articulations of different aspects of perception and Labanotation when I discuss descriptions of movement in relation to technology.

2.3.2 Using Aspects of Labanotation to Extend Descriptions of Movement in Relation to Technology

The *structural* form of Labanotation provides descriptions of movement in terms of:

- the *body and its parts* (which part of the body is moving);
- *space* (direction, level, distance, degree of motion);
- *time* (metre and duration); and
- *dynamics* (quality or texture, e.g. strong, heavy, elastic, accented, emphasised).

In Chapter 4 the *structural* form of Labanotation is extended with the use of movement scripts. Here I briefly consider each of the above Laban terms.

The Body and its Parts

Movement of the *body and its parts* takes place through the body's musculoskeletal and nervous system. The use of movement for interaction control relies on the natural paths of movement determined by the mechanics of the joints and flexion and extension of muscles and tendons. As such, the human body provides both constraints and resources in the determination of possible movement profiles, as well as an indication of which parts of the body could be suitable for different types of interaction and different types of wearable technology (e.g. Barfield et al. 2001).

According to Laban, the first things to focus on when observing bodily actions are what parts of the body are moving. Laban uses examples such as *upper or lower part of the body*, is the *body off or on the floor*, is the *body symmetric or asymmetric*, is the

movement simultaneous or successive in one or both limbs and so on (Laban 1971, p. 53).

In the following I describe some typical movements involving interactions with technology. I use three examples, using a mouse, interacting with an automatic door and playing Eyetoy™, throughout the rest of this chapter in an attempt to highlight the different aspects of Laban's terms. See Table 2.1.

Table 2.1: Uses of the body and its parts in interaction

Example	Description
Mouse	When using the mouse we use one or several fingers and the hand, the lower arm is usually resting on a horizontal surface.
Automatic door	When using an automatic door we use the whole body, usually oriented front or side on to the door.
Playing Eyetoy™	When playing Eyetoy™ we are standing with the torso upright, we are using the hands and arms, or the legs can be used if we are flexible enough.

In these scenarios, the body (and its parts) and movements are *used* to issue commands that technology responds to, the click of the *right* mouse key or a key on a keyboard. With an automatic door, the body or parts of the body are merely *present*; this is enough to trigger interaction. Similarly, the presence of the finger or stylus on the screen is used to indicate a starting point (for example, on screen writing on PDAs).

Space

Space as in *direction, level, distance and degree of motion*, is another basic characteristic of movement (Laban 1971). It describes:

- In which direction(s) the movement is going or is exerted;
- In which plane (height, width, depth);
- At what level (by the feet, hips, torso, shoulders or above the head, etc);
- How far (e.g. number of steps); and
- With what degree of motion.

Laban used the standing body in ballet's first position[5] as a baseline or point of reference. In technology design, the point of reference can be adjusted to a specific body part, a person or a group of people moving in a space, an external event trigger, task list or an object, or it can be adjusted to the dimensions of the space where the interaction is taking place. See Table 2.2.

Table 2.2: Uses of space in interaction

Example	Description
Mouse	When using the mouse we lift the fingers up and down and move the hand across a (two dimensional) surface guided by the reference given by the screen.
Automatic door	When using an automatic door we move the whole body, usually oriented front or side on to the door.
Playing Eyetoy™	When playing Eyetoy™ we move the hands and arms next to and across the body oriented front on or side onto the camera and screen determined by the game.

Orientation or positioning is an important aspect of space. In technology design, both the orientation of the person and the technology is important. For example, both a body and a remote control must be oriented in the right direction, if visual output is provided or for a TV to be turned on or off.

Using space, movements can be sensed and responded to without the aid of a traditional pointing device such as a mouse or stylus, but using other virtual and physical objects for pointing and positing, for example, using mobile phones (Ballagas et al. 2004, Ballagas et al. 2005) or a remote control as a pointing device (Kela et al. 2006, Kim et al. 2004b). Many interactions require the use of physical objects alongside the body, to enhance or engage the system, for example, remote controls, gloves, goggles, to mention a few. *Charade* (Baudel and Beaudouin-Lafon 1993) used a glove to enable interaction through hand movements. Tangible bits or moveable objects are common in tangible computing; the objects are tagged and tracked and are used as tangible input elements that can be moved both by users and by the computer (e.g. Rosenfeld et al. 2004). Depending on the sophistication of a system, it will either treat the objects as part of the human form, or be able to distinguish the object from the human body.

[5] In ballet's first position the dancer is aiming to form a straight line with the feet. The feet face outward, the back of the heels are touching, the balls of the feet are completely turned out.

The use of virtual and physical objects relies on the research which has been conducted on input devices. Much of this research has focused on input options by extending the capabilities of devices by developing new devices and related techniques for the manipulation of objects. Examples include:

- designs based on a metaphor of changing the length of the virtual arm (e.g. Poupyrev and Ichikawa 1999, Bowman and Hodges 1999);
- extending the capabilities of current devices to suit new technologies, tasks and environments, in tangible interaction (e.g. Ullmer and Ishii 2001); and
- combining multiple modes into multimodal interaction (e.g. Oviatt et al. 2003).

More recent developments include the Nintendo Wii™ (2006) and Apple's iPhone™, iPod™ Touch (2007) and iPad™ (2010). The Wii™ has a set of wireless controllers that users hold to play its games. With the Wii™, a player makes movements in space with a controller and the movements are then reflected in some way on-screen. Buttons on the Wii™ controller makes it easier for technology to detect the start and end points of a movement. The iPhone™, iPod™ Touch and iPad™ are devices that are controlled using touch screens. They also have sensors detecting the orientation of the device.

Time

Time, as in *metre* and *duration*, as a characteristic of movement, describes the tempo or progression of movement such as quick and slow movement and repetition of movement. On the mouse, mobile phones and game consoles, different functionality is activated with single-clicks, double-clicks and continuously holding a button down (pressure). The difference between a single-click, a double-click or holding a button down is determined by the interval between clicks. For example, sustaining pressure on a game console when playing a golf game makes the golf ball go further. That is, we can have the *illusion* of more pressure, i.e. a longer press before letting a button go corresponds to a harder hit. See Table 2.3.

Table 2.3: Uses of time in interaction

Example	Description
Mouse	When using the mouse we must rapidly double-click a filename to open a file.
Automatic door	When approaching an automatic door, the rate at which we approach will determine whether the door will open or not (approach too quickly and the door remains closed).
Playing Eyetoy™	In Eyetoy™ we slowly wave the right hand over the projected button on the screen in front of us to confirm our choice guided by the projection on screen.

Ironically, the mode of interaction for Eyetoy™, the hand or another body part being present in the right space at the right time, is not dissimilar to the finger hitting the *right key* at the *right time*. Yet the way Eyetoy™ technology allows, rather than enables, a variety of movements in order to get to the point of interaction was novel when it was first released. This mode of interaction, *the right place, at the right time*, is also the mode of interaction in the arcade game, Dance Dance Revolution™ (Konami® 2003). In this game, the game controller consist of four different sensors placed on the ground, and the interaction takes place by stepping on these sensors in different patterns indicated on a screen in time with music.

Dynamics

Dynamics describes the way in which a movement is carried out in terms of degrees of muscular energy spent on a movement, its *texture*, whether it is *strong, heavy, elastic, accented, emphasized* and so on. It can, with Laban's *effort-shape* (Hutchinson 1977) descriptions, be used to further describe the dynamic characteristics or qualities of movement. For example, reaching out for a glass and punching someone both rely on the extension of the arm, hence they are not very different in terms of the organisation of the body and its parts in time and space. However, the strength, control and timing of the movement are of very different character. An example of interactions enabled through dynamics of movement is the use of *tilt* in order to scroll on a device (e.g. Oakley et al. 2004).

The *dynamic* aspects of movement are perhaps the most difficult to observe and also describe. For the examples I have used, the *mouse*, the *automatic door* and the *Eyetoy™*, the dynamic qualities of the movements in the interaction are not encouraged, detected nor relevant. Only the fact that the button was pressed and the presence of the body in a space matter. However, in the Nintendo® Wii™ (2006) controller, the use of accelerometers enables the dynamic aspects of movement to be sensed and used for interaction.

Summary: The *structural* form of Labanotation allows the description of movements in interaction in terms of the body with its parts in time, space and dynamics. See Table 2.4, which summarises the use of these four aspects of Labanotation to extend descriptions of movement in relation to technology. We see that movements rely on detecting the body or body parts and movement in space and time. From there we can describe interactions in terms of the presence or absence of movement in two-dimensions. In the examples I have provided here, the dynamics of movement used for interaction are not generally addressed, encouraged or sensed by the technology.

Table 2.4: Movement in relation to technology with the structural form of Labanotation

Example	Body, body part	Space	Time	Dynamics
Mouse, clicking the mouse	Fingers, hand and lower arm, (eyes across visual surface).	Movements of the fingers vertically (up-down), movement of the hand horizontally/ the x-y plane (2D) (across a surface).	For a single click, one needs to let go eventually. For double-clicks the right rate of repetition needs to be achieved.	Dynamics are generally not encouraged, detected nor relevant. Only the fact the button was pressed matters.
Walking towards an automatic door in order to open it	Whole body, or part of body in detectable area, oriented front or side on to the door.	Movement is directed towards or past the automatic door.	Presence of a body part or approach of a body in the appropriate space and at an appropriate speed will open the door, which will stay open for a specified amount of time or when the body disappears.	Only the presence of a body or limb in the areas of the sensors matters.
Making a selection, playing Eyetoy™	Hands, arms, torso, (legs, if flexible).	Movement vertically next to and above torso, movement across torso.	When making a selection, the "right" rate of movement with the hand needs to be achieved.	Only the presence of the hand or other limbs in the areas of the sensors matters.

In section 2.3.1, I described a number of frameworks that use movement in interaction, e.g. by explicitly focusing on the body or movements of the body in the interaction, on tangible aspects of an interaction, on using movements for artistic expression or bodily perception, on the space in which the interaction takes place, on the sensors and movement of the technology and so on. Some of the specific examples were interactions where the body is the interface for interaction (e.g. Burton-Apple ski jacket or MP3 player used when exercising), the body is used for input and interaction control (e.g. Eyetoy®, Tai Chi in VR (Chua et al. 2003)), the body is used to inspire interface and interaction metaphors (Mine et al. 1997, Ängeslevä et al. 2003). However, these frameworks mostly focus on the whole body or generalised

movement of a body part in an interaction. Using aspects of Labanotation as I did in this section, I was able to be more specific about the body part and the nature of the movement involved in the interaction.

2.3.3 Sensors

The examples of the previous sections are illustrative of the ways many interactions with technology use sensors. Although, far from the main topic to be dealt with in this thesis, the types of movement and the ways in which movement might be used in an interaction are often influenced by factors such as the number, placement and dimensions of sensors, as well as the activity (see e.g. Michahelles and Schiele 2003). These factors will influence both the quality of the sensing and put constraints on the movement and types of movements in an interaction. Table 2.5 provides some examples.

Table 2.5: Common sensors for movement

Sensor	Description	Example
Motion	Detects movement and speed, Positioned in the environment	Automatic door
Pressure	Detects whether something is being touched or alternatively stood on	Touch screen, Dance Dance Revolution
Proximity/position	Detects position and direction	Moving an RFID tag near a cash-register
Gyroscope/ accelerometer	Detects orientation, i.e. size, shape, speed and acceleration of movements in three dimensional space	Mobiles and digital camera changes orientation of screen if tilted (landscape or portrait)

Handheld technologies as well as wearable technology can be used with sensors located in the environment. The technology can then be hosted on the body, the body is used as the interaction surface, and the interaction is tangible. For handheld devices, the device must usually be positioned so it is directed towards the sensor(s). For wearable technology, the location of the technology is the reference point for the movements used for interaction. When the sensors are positioned in the environment, individual parts of the body or the whole body is tracked. Depending on the positioning of the tracking device (above, side, whether the technology is stationary or mobile, etc) there is a potential for movements of the body to proceed in all directions, though within the capabilities of the sensors.

Tangible, wearable and handheld technologies (such as the mouse, touch screens, tangible bits and technology embedded in clothing) are technologies that make use of the body and particularly the dexterity of the hand for interaction. Barfield et al.

(2001), Baber and Bauman (2002), Thomas et al. (2002), Teller (2004), Knight et al. (2005) and Biehl et al. (2006) are some researchers who have looked at issues of embedding technology in clothing or wearing/carrying technology on the body (e.g. an MP3 player in the pocket and the control around the neck). As well as investigating issues of using measures, such as location on the body, to determine suitable areas for placement and interaction, their research looks at how to use the body and its surfaces to host technology. Some of these tangible interactions use *direct manipulation*, that is hand movements, as a form of interaction. The efficiency and experience of use of direct manipulation has been thoroughly established in HCI since it was introduced by Shneiderman in 1983 (see also Hutchins et al. 1986). Wilson's book *The Hand: How Its Use Shapes the Brain, Language, and Human Culture* (1998) sheds further light on why the hand, and consequently direct manipulation, is such a powerful style of interaction, by describing the evolution of the hand and its effects on the brain, motor and language development and psychology.

With new multi-touch surfaces, designers can now combine a number of touch points, allowing people to use more than one hand at a time for interaction, for example, to drag the opposite corners of an image to enlarge the image, or allow other combinations of movement to happen at the same time. Such *multi-touch* surfaces, with software that recognises multiple touch points simultaneously, were publicly demonstrated to much accolade by Jeff Han at the TED 2006 conference (Technology, Entertainment and Design) (online).

Summary: Although not a major focus of this thesis, sensors permit the interactions between movement and technology which are being studied here. I now move on to the subjective experiences of movement in technology interaction, particularly in relation to the design of interaction.

2.3.4 Subjective Experiences of Movement as Object for Investigation in Interaction Design

A research and design focus on the subjective experience of interaction is more common in HCI than a focus on subjective experiences of movement in technology interaction. In HCI, issues of user experience or experiential qualities of interaction are often discussed within a discourse of the aesthetics of interaction and aesthetics of interaction design (Djajadiningrat et al. 2000a, Fels 2000, Hummels 2000, Petersen et

al. 2004, Dunne 2006, Moen 2006 and Hummels et al. 2007, Löwgren 2007a, 2007b and 2009). For example, Hummels (2000) describes the aesthetics of interaction as *the sense of beauty which arises during the interplay between a user and a product in their context*. Other aspects, such as *affect* (Picard 1997 and 2003, Picard and Klein 2002), *emotions* (Norman 2004c), *fun* (Blythe et al. 2003, Gaver et al. 2004), *pleasure* (Djajadiningrat et al. 2007), and *felt life* (McCarthy and Wright 2004, Light 2006 and Light 2008), are used to describe and discuss aspects of use and qualities of designs. Most closely related to my research are researchers who have suggested or used Shusterman's (1997) pragmatist aesthetics and somaesthetics (Kallio 2003, Petersen et al. 2004 and Fiore et al. 2005), somatics (Schiphorst and Anderson 2004, Schiphorst 2006 and 2007) and *KinAesthetics* (Moen 2006) as potentially useful approaches for interaction design and user experiences. I would also argue that Robertson's (1996, 1997b, 2000 and 2002), Svanæs' (2000 and 2001) and Dourish's (2001 and 2004) focus on embodiment is not a separate approach to understanding user experience, but is a foundation for the above mentioned approaches.

Moen's Bodybug™[6] uses the concept of KinAesthetic movement interaction, which she described as *designing for the pleasure of motion*. The Bodybug™ is *...a movement-based interaction concept that uses bodily movements in order to create a physical dialogue between you and the artefact, as well as with the environment* (Moen, 2006, p. 113). *KinAesthetic* movement interaction can be described as a use quality for the Bodybug™. That skilful manipulation of objects can be an aesthetic experience is echoed in Fels (2000). McCarthy and Wright's (2004) notion of *felt life* explores the interplay of *aesthetic, sensual* and *emotional* aspects of our engagements in the world, with the aim of providing a richer set of concepts with which to understand *the human* in human-centred design. The kinaesthetic and proprioceptive senses are also accounted for, to some extent, in applications using haptic technology in the teaching of bodily skill, for example, for dentistry practice (e.g. Campbell et al. 2003 and Cederman-Haysom and Brereton 2006) or drawing (Keefe et al. 2007). Another interesting example is Couvillion et al.'s (2002) use of pressure mats for navigation in virtual environments. Couvillion also mentions experimenting with the

[6] The BodyBug™ runs along a wire and an accelerometer senses the movements of the person wearing/interacting with it, using movement both for input and output.

use of visualisations of pressure on pressure mats to retrain impaired balance and proprioception.

Pliability, rhythm, dramaturgical structure and *fluency* as experiential qualities have recently been further developed by Löwgren (in 2007a, 2007b and 2009 from Löwgren and Stolterman 2004). Löwgren does not advocate a particular design methodology, but suggests attention to experiential qualities, in the use of interactive products and services as a way to improve designers' assessments of a product or an interaction. He wrote:

> *...it should be noted that many designers in fields such as augmented spaces (e.g., ubiquitous computing, peripheral interaction and tangible interfaces) are guided in their design work by values similar to the one I try to capture in the experiential quality of fluency, even though they generally do not step back and articulate these values.* (Löwgren 2007b, p. 7)

Hämäläinen (see e.g. Hämäläinen et al. 2005), one of the designers of *Kick Ass Kung-Fu*, an artificial reality martial arts game preceding both the Eyetoy™ and Wii™, expressed a sentiment articulating a design approach embodying experiential qualities:

> *In my designs I aim to recreate the feeling you have when as a child you get up one morning and run barefoot through the grass* (Hämäläinen, personal communication)

Two notable interdisciplinary approaches addressing experience can be found in Wakkary et al. (2004) and Candy (2007). Wakkary et al. called for a *re-dressing of methodological practice* for exploring, building, communicating and prototyping of experience. Candy suggested applying insights from fashion design about the performance and expression of personal style to the study of human embodiment and subjective experiences of movement enabled technology.

Summary: The Bodybug™ is one of a few examples of technology interactions designed with considerations for the kinaesthetic and proprioceptive senses as a starting point. This is also my approach in this thesis. However, as I discuss in the next section, more interaction designers are adopting and developing design approaches that incorporate subjective experiences of movement in both design and evaluation of technology.

2.3.5 Doing Design about, for, from and with Experiences of Movement

The increased focus on aspects of subjective experience and experiential qualities in HCI is, in part, influenced by methods from art, design and performance. This trend sees the adoption in HCI of methods for design as well as evaluation. Technology is no longer evaluated according to normative criteria only, but also by harder to pin down values such as aesthetics of use, fun, fluency and so on. Embodying these influences, several methods and design approaches have been developed in HCI and neighbouring fields. They advocate explicit and focused bodily involvement by both designers and potential users as part of the design process, e.g. Djajadiningrat et al. (2000a, 2004 and 2007), Schiphorst (2006 and 2007), Schiphorst and Andersen (2004), Jensen (Jensen et al. 2005, Jensen 2007 and 2008), Klooster and Overbeeke (2005), Moen (2006, 2007), Hummels et al. (2007) and Loke (2009).

Choreography of interaction, a method developed by Klooster, was used to develop the design of a vase from the movements involved in flower arranging. The final design of the vase is based around four principles that were developed when experimenting with arranging flowers. Klooster used movement both for creating and evaluating the interaction. Djajadiningrat et al. worked from ideas of building specific bodily skills, akin to skill development in traditional crafts, playing an instrument or sports. They see skill building not only as a potential outcome of a movement enabled interaction, but skilled action as a way of thinking about designing interaction with products. This necessitates thinking in terms of the enjoyment of the experience of use (or learning), rather than just the ease of use. Jensen has been working from the same ideas, using the *hands-only scenarios, metaphor lab, string of actions*, and the *video action wall* as ways and activities through which qualities of movements are identified and kept present throughout the design process. Moen's KinAesthetic Movement Interaction uses theories and methods from modern dance. Her BodyBug™ concept, mentioned above (section 2.3.4) was developed from the experiences of a group of people participating in a movement/dance class. Similarly, Schiphorst and Andersen developed *whisper*, a wearable public installation, using performance-based methods such as improvisation, props and phantom partners. They said:

> *The goal of the work-shops was to model experience that could be replicated, re-enacted, and re-played in the context of a public art installation using wearable computing technology* (Schiphorst and Andersen, 2004, p.2)

Schiphorst (e.g. 1977, 2004, 2006 and 2007) has, throughout her career, been working with *somatics* or what can be termed *first-person methodologies* to develop a number of artworks and installations, working from the experiences of the designers as well as the people experiencing her works. The work of Hummels et al. (2007), Loke (2009) and Loke and Robertson (2009) are more directed at activities for designers and performers. Hummels et al. developed the Attending Theremin, among other tools, for designers to explore what they call the *expressive power of gesture*. Loke's framework of *Moving and Making Strange* suggest designers engage in bodily inquiries in order to re-examine and revitalise their assumptions and conceptions of the moving body in the design and evaluation of interactive technologies. Common to all these approaches is a focus on the designers, or designers' and users' explorations through movement before explorations of form and the appearance of the technology.

Another line of work strives to gain insight or sensitise designers to a particular context of use and create empathy with a group of users without focusing explicitly on specific movements. Sometimes this is combined with activities that trigger reflection in study participants (e.g. Gaver et al. 1999, Paulos and Beckmann 2006). Examples are:

- The work involving user-centred and participatory design by Forlizzi and her colleagues (Forlizzi and Ford 2000, Forlizzi and Battarbee 2004);
- Experience prototyping (Buchenau and Fulton Suri 2000);
- Bodystorming (Oulasvirta et al. 2003); and
- Movement oriented personas and scenarios (Loke et al. 2005b).

The approaches for doing design about, for, from and with experiences of movement range from understanding a design space, to creating empathy with users, to generating inspiration for design concepts, to gaining insight into context of use, to generating requirements and evaluation of concepts and design. The approaches involve methods that do not focus directly on movements and also those that engage the body of the designer and potential users in particular settings. In technology design, these issues have been mentioned by, among others, Reeves et al. (2005), Moen (2006), Candy (2007) and Dix et al. (2008).

2.3.6 Section Summary

In this section, I have described some of the ways in which technology currently uses movement. Technology often relies on the *moment of interaction*, meaning that the *presence* or *absence* of movement is what the technology really cares about regardless of the movement taking place with a device or *free to air*. However, for my work, I suggest that it is important to not see a movement in isolation, to study the movements themselves, and find appropriate tools to describe and discuss movement. To address this, I described in some detail how Laban's work could be used to extend descriptions of movements as they generally show up in interaction design today. Complementary to paying closer attention to description of movement are approaches that use subjective experiences of movement of both designers and potential users as starting points for or input into the design process.

From here, I move on to outline how we can begin to describe kinaesthetic and proprioceptive experiences in interaction design.

2.4 Kinaesthetic and Proprioceptive Experiences as Experiential Qualities

Earlier in this chapter, in section 2.2.3, I described the perceptions that make up our experience of our own movement: proprioception and kinaesthetic perception as our ability to perceive the position of our body in motion; active and passive touch; spatial perception and frames of reference; perception with tools and from Merleau-Ponty, I borrowed the concept of body schema, which he provided as a way of explaining how we organise our perception and action. These become important in order to access and understand subjective experience of movement in relation to technology in this thesis. In section 2.3.1, I described different frameworks for using the whole body or movement of a body part in an interaction. By incorporating aspects of Labanotation (section 2.3.2) I was able to be more specific about the parts of the body and the nature of the movement involved in the interaction.

By combining considerations of subjective experiences of movement descriptions of the body and its movements in interaction with technology, four areas stand out as being important characteristics of interactions through movement:

- Whether there are *tangible* aspects to the interaction;

- The *proximity* of the technology and movement for interaction; and
- Whether *dynamic* or *expressive* aspects of movement are considered for interaction.

The fourth area is Merleau-Ponty (1962) *body schema* which act as an unifying agent by which we organize perception and action:

In Table 2.6 below, I expand on this by first returning to the examples from section 2.3.2, clicking a mouse, walking towards an automatic door and playing or making a selection in Eyetoy™.

Table 2.6.: Tangibility, proximity and dynamics applied to interaction through movement I

	Click mouse to print	Walking towards an automatic door in order to open it	Making a selection in Eyetoy™
Tangibility	Mouse is being held.	No tangible element.	No tangible elements.
Proximity	Interaction is enabled within bodily reach.	The proximity of the whole body to the door's sensor will determine whether the door will open or not.	Movement for interaction takes place within bodily reach, around the body in the environment.
Dynamics	Dynamic or expressive use is allowed, but not detected.	Dynamic or expressive use, e.g. walking towards the door with a bouncing walk, will not alter interaction.	Dynamic or expressive use will not alter interaction.

I then apply the same consideration to two examples from section 2.3.1, training Tai Chi in VR (Chua et al 2003) and a design framework based on utilisation of proprioception (Mine et al. 1997). See Table 2.7.

Table 2.7: Tangibility, proximity and dynamics applied to interaction through movement II

	Training Tai Chi in VR	Design framework based on utilisation of proprioception
Tangibility	Technology is hosted on the body.	Technology is hosted on the body as well as in the environment.
Proximity	Movement for interaction takes place around the body in the environment.	Movement for interaction takes place on the body and around the body in the environment.
Dynamics	Dynamic or expressive use will not alter interaction.	This is a design concept, so dynamic and expressive use would result in different interaction outcomes.

With all these examples, over time the technology and the movements needed to enable interaction are incorporated into our bodily space, and we are reliant on the potential for action that the technology creates for us. In all five cases, the interaction

is designed according to the capabilities of the technology in terms of the capture and interpretation of information. This poses both constraints and opportunities for our movements. Although technology might be good at capturing information, as Svanæs (2001) emphasised, what an action *means* always depends on the intentions of the user as well as the context within which the action is interpreted. From the point of view of kinaesthetic and proprioceptive experiences, what makes a system or a device good to use is dependent on the movement relations that can be created and that are performed between the user and technology, whether the technology is being held in the hand, hosted on the body or in the environment.

Based in the considerations in the proceeding section and my understanding of how we perceive our physical selves in space and how we perceive when acting through things, I propose consideration of movement relations in terms of *body schema, tangibility*, *proximity* and *dynamics*. These four terms can be used as orienting and sensitising principles when seeking understandings about movement and movement experiences in technology design and technology use. They also become the point from which I ground my conceptualisations in this thesis.

> Body schema – the background to our capacity to organise our bodily movements. It is modified by our movements and activities.
>
> Tangibility – the presence, absence or combination of tangible and non-tangible aspects in an interaction as determined by whether the interaction involves touch or "just" free-form movement.
>
> Proximity – the "layers" of proximity as in the distance between the person moving and the technology, determined by whether the technology is held in the hand, hosted on the body, or in the environment.
>
> Dynamics – the extent to which expressive qualities of movement are encouraged or allowed as part of enabling the interaction degree, including expressiveness, qualities of movement and effort expenditure.

Body schema "operates" as the background, and thus provides an understanding of how we put experiences together. Tangibility is to be understood as a continuum from the tangible close to or on the body, to the handheld, to moving free-to-air with sensors in the environment. It is dependent on proximity in the sense that if an interaction is taking place within reach, the sense of touch can be engaged. An interaction taking place out of reach can still be tangible, but only as a sensed movement in space without the sense of touch being involved. The dynamics

dimensions are relevant for both tangible and non-tangible interaction. For example, an interaction can be reliant on skill and the particular expressiveness of free-form movement as well as skill and expressiveness with a device.

2.5 Research Question

The *moving body in technology interaction* is the context for my work and its contribution. I believe there is an opening for research that combines the use of movement to enable interaction while attending to and trying to understand subjective experiences of moving with technology and designing technology with and for use with movement. The aspects of the subjective experiences I explore involve perceptions of touch (tangibility), perceptions of space (proximity), perceptions of dynamic aspects of movement (dynamics) and an understanding of how we put these experiences together (body schema).

The remainder of this thesis makes use of these concepts in the process of understanding kinaesthetic and proprioceptive experiences of interaction with technology. As I stated in the introduction to this chapter, interactions with technology, as with all our interactions in the world, engage all our senses. Without the kinaesthetic and proprioceptive senses, it would be difficult for us to move ourselves and to move things. However in HCI, the kinaesthetic and proprioceptive senses are much less understood than the visual sense. Although this is changing, few interactions and technologies are currently designed with considerations for the kinaesthetic and proprioceptive senses as a starting point. Hence, I am studying these senses to provide a fuller understanding of experiences of use by focusing not just on *how* an interaction might *look*, but also on *how it might feel* to interact with technology.

If we take the moving, perceiving body as our point of reference, as I have done, and look at the way movements are used in current interaction design, the central theme of this thesis is:

> *How can kinaesthetic and proprioceptive experiences as an experiential quality be accounted for in technology design and the study of technology use?*

Applied to the design of technology, this would be phrased as:

> *How and what makes a technological system good to use from the perspective of the kinaesthetic and proprioceptive senses?*

2.6 Chapter Summary

In this chapter, I have reviewed a number of potentially useful concepts for the purpose of coming to a better understanding of kinaesthetic and proprioceptive experiences as an experiential quality of interaction with technology. This chapter described how movement in an interaction with technology can be considered from various perspectives:

- Movement as an object and as means;
- Movement as subjective experience; and
- Movement as knowing and understanding.

These perspectives disclose and highlight different aspects of movement of relevance when considering interactions with technology. I discussed concepts and theories for reasoning about the different ways in which movement is used in interactions, the experience of interacting with technology enabled through movements of the body, and also ways of moving and designing for and with movement. This engagement with and through movement is the focus of an emerging trend in the design process in HCI and neighbouring fields. I developed my analysis from a position informed by Merleau-Ponty's phenomenology (1962), taking the body with its embodied capacities for perception and action, as my point of reference.

Next I present how all these elements were translated into a series of three studies focusing on *movement*, *experience* and *design*, respectively. I describe the studies that were performed, their rationale and how these enable me to explore and address the research problem.

Chapter 3
Method: Researching the Moving Body in HCI

Three studies form the empirical basis for this research. These studies were undertaken in phases: each phase was used to refine the research questions and to determine the appropriate setting and methods for data collection and analysis for the next study. In this chapter, I describe and discuss the research design, the rationale for the overall methodological approach and the methods chosen for the three studies.

> *Embodiment as a paradigm or methodological orientation requires that the body be understood as the existential ground of culture-not as an object that is "good to think," but as a subject that is "necessary to be."* (Csordas 1993, p. 135, quotations in original)

> *The ethnographer enters the field with an open mind, not an empty head.* (Fetterman 1989, p. 1) *and, we might add, with an experienced body* (Stoller 1997, p.43).

As stated in Chapter 1, the questions and motivation for this research evolved from my readings, experiences, observations and reflections as an interaction designer as well as a movement practitioner. In the following sections, I describe how these elements were translated into a series of three studies that enabled me to explore and address the research problem. Each of the three studies – the approach, the method, participant demographics, data collection and analysis – will be described in detail in Chapters 4, 5 and 6, respectively. In the first half of this chapter, I briefly describe each study. However, my emphasis here is on the evolution of the research, that is what happened *between* the studies - how I moved from one set of research questions in one study to a more refined set of questions in the next study. In the second half of the chapter, I discuss and reflect on my choice of methods, the overall research design, methodological issues such as perspective, my role as a researcher and on negotiating issues of reliability and validity with this type of research. The overall framing of the research and the interpretation of the studies form the basis for the theory generation in this thesis.

3.1 From Curiosity and Theory to Empirical Studies: Evolution of the Three Studies

I stated that the aim of this thesis is to come to a better understanding of kinaesthetic and proprioceptive experiences as an experiential quality of interaction with technology. The overarching question for my research is:

> *How can kinaesthetic and proprioceptive experiences as an experiential quality be accounted for in technology design and the study of technology use?*

The three studies that form the base of the empirical work in this thesis use a range of approaches, some common to HCI, others borrowed from or inspired by work in areas such as ethnography, dance and movement studies. In order, I study *use*, *experience* and *design*, that is the *use* of technology enabled through movement of the body, the *experience* of moving, and finally movement as a material for *design*. The three

studies were developed in phases using an iterative design process, that is each phase was used to refine the research questions and to determine the appropriate setting, methods for data collection and analysis for the next study.

3.2 Study I: The Eyetoy™ Study: Describing and Representing Movement for Interaction

The focus of the first study was the use of design representations, analysis and frameworks for design. In HCI and related fields, several approaches exist for describing and representing interactions, the movements used in interactions, and the relationships between the movements and the corresponding responses from technology. As such, this first study was heavily informed by literature. In preparation for the study, we identified four frameworks and approaches for describing and representing movement in HCI and movement studies. The approaches were then used to explore and analyse the use of movement for interface and interaction control in a study of two Sony® Eyetoy™ Playstation2® games. The movements used to enable interaction with the game, the relationships between bodily actions and the corresponding responses from technology were analysed with interaction analysis (Suchman 1987), two design frameworks (Benford et al. 2003 and Bellotti et al. 2002) and movement analysis (Hutchinson 1977). The study had eight participants, four female and four male. The participants varied in age, computer game experience and level of regular exercise. The study took place in Sydney, Australia in February 2004.

3.2.1 Data Collection and Analysis

This first study explored movement as input for interaction through a study of two Eyetoy™ games. The Eyetoy™ games rely on movement as input to enable interaction. There is no controller, joystick or similar device to play the game, as such a player has no direct physical contact with the technology. The games can be played using movements of any part of the body, but tend to be played mainly with movements of the torso and arms. While playing, the player can see a projected image of his/her body in the middle of the screen, overlaid on the gamescape. The player's movements are used to drive the interaction by coinciding spatially and temporally with buttons and game events that form part of the gamescape. During game play, only certain areas of the screen are deemed active (by the system) at any point in time depending on the game context. Active, in this context, means that a player's movements in

relation to particular areas of the screen can be sensed by the camera and so registered as input. A diagram of the study setup is presented in Figure 4.3.

Two games, Beat Freak (see Figure 3.1) and Kung Foo (see Figure 3.2), were selected based on an evaluation of the range of movements the games elicited, as well as how easy the games were to learn.

Figure 3.1: Beat Freak game

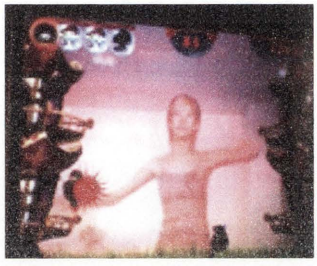


Figure 3.2: Kung Foo game

The four analysis frameworks provided us with ways to explore descriptions and representations of bodily movements enabling game play with the two Eyetoy™ games, as well as other movements performed while playing. Suchman's (1987) framework for *interaction analysis* enabled us to see the communicative resources available in the interaction. The bodily movements used in the interaction were first transcribed then analysed using *Labanotation* (Hutchinson 1977). The two design frameworks, Benford et al.'s *Expected, Sensed and Desired: A Framework for Designing Sensing-based Interaction* (2005), and Bellotti et al.'s *Making Sense of Sensing Systems: Five Questions for Designers and Researchers* (2002) allowed two different views of the relationships between the bodily movement and the technology. This study is described in detail in Chapter 4.

3.2.2 From Study I to Study II

The first study enabled me to work with existing frameworks in HCI to consider and understand relations between bodily movements in an interaction with this specific technology. The understandings and considerations that developed out of the first study, as well as the reading I had done up to that point, left me with two different, but related questions. The first question concerned the description of movement. The study seemed to lack descriptions of the lived experience of playing the two games, that is, descriptions of the experiences of moving or performing the movements that enabled the interactions with the game (i.e. technology). Of the four frameworks, only Labanotation considers and describes the movements in the interaction, and whether

Labanotation is a subjective or objective (first-person versus observer's) account of movement is the topic for discussion, for example, in anthropology (see e.g. Farnell 1996 and 1999). Laban argued that Labanotation is written from the actor's perspective, rather than the observer's and so has built-in assumptions of agency (Hutchinson 1977). It is also argued that Labanotion is *just* an anatomical description of movement and that it reduces action to positions or a sequence of positions similar to photographs, sketches and diagrams (see Farnell 1994 for a discussion on this). More specifically, my first question concerned possible additional aspects to the description of movement not addressed with the frameworks and approaches used in the first study. What could these additional aspects be, how could they be addressed, accessed, and how could this get me closer to articulation and descriptions of kinaesthetic and proprioceptive experiences in technology design and technology use?

The second question arising from the first study concerned the understanding of movement and movement literacy as a potentially useful skill in interaction design. In the planning stages of this first study, all twelve games in the Eyetoy™Play release were explored to identify the most suitable games for the study. By a *suitable* game we meant games that were seen to elicit a range of movements while at the same time being fairly quick and easy to learn. The selection of the two games, Beat Freak and Kung Foo, was an outcome of this process. In addition, the process of transcribing (first using handwritten Labanotation then digitisation) and analysing the movements used for gameplay required examination, re-examination and close observation of both the recorded movements and our transcriptions. The usefulness, or rather necessity, of our re-enactment, that is moving, as part of this process, became increasingly apparent to me over time. The re-enactment would take the form of replaying the games, repeating and copying the recorded movements (both from notation and from digital video recording), and moving according to the description of Labanotation in Hutchinson (1977), while refining the transcriptions. In our analysis, this process of transcription forced a certain rigour upon the movement analysis as the two researchers had to agree upon the transcribed form in order to have a common understanding of the analysed movements. Reflecting on this process, I realised there were questions to be investigated about how to develop and represent both individual and shared understandings of movement within interaction design practice.

Since the first study was undertaken, I have come across several methods and design approaches advocating explicit and focused bodily involvement by both designers and potential users as part of the design process, (e.g. Djajadiningrat et al. 2000a, 2004 and 2007, Schiphorst and Andersen 2004, Jensen 2005 and 2007, Klooster and Overbeeke 2005, Moen 2006 and 2007, Hummels et al. 2007). Common to these approaches is a focus on explorations through movement of the interaction and movements used to enable interaction, before explorations of the form and appearance of the technology. In their paper describing the *Choreography of Interaction* approach, Klooster and Overbeeke say,

> *We realize that theoretically describing this approach is a nearly impossible venture. In fact, only through movement, through practicing it, the idea can actually be grasped.* (2005, p.23)

While I agreed with the inherent challenge in verbally articulating these issues, I felt that further investigation could help me better understand the issues, further inform my ability to reason about them and possibly also enable me to talk about them. The two questions that emerge from the first study, combined with the considerations from these design approaches, came together to form the impetus for the second study. The next section describes how I framed the next part of the research for this thesis project.

3.3 Study II: The Nature of Kinaesthetic and Proprioceptive Experiences: A Study of Understanding and Knowing

In order to address the two questions arising out of the first study, two topics crystallised for the second study, i) *experiential descriptions* of movement/moving, and ii) the *nature* of experiential bodily knowing and understanding generated through experiences of the moving body, that is, the coming *to know* of bodily skills. In relation to interaction design, I wanted to explore what this could mean as a type of understanding and knowing in interaction design practice. Both research questions are relevant as they contribute to extend our understanding of both use and design, and therefore overall user experience.

In order to understand the experience of moving, I decided to look for ways to explore the processes of becoming a skilled mover, i.e. the processes through which movement experiences are first grasped and then realised. This led me to consider movement disciplines with varying degrees of focus on awareness in movement, and from studying movement practitioners in these disciplines, obtain experiential

descriptions of movement as well as understandings of the nature of experiential knowing. Becoming a skilled mover is analogous to becoming skilled in a *craft*, for example, knitting, boatbuilding, midwifery or programming. As discussed in the previous chapter (section 2.2.4), craft implies skilful handling and interaction with materials and tools; it means a person develops the ability not only to do the movement required to carry out an activity, but also to improvise and play with movement. In relation to interaction design, using the term craft addresses the connections between perception and skill in studying and developing understanding in design. Both movement disciplines and craft develop through improvisation and skilful interaction by skilled practitioners that push the edges of the current rules and styles of a discipline, leading to the development of new techniques and new tools. A few examples are the Fosbury flop in high jump, the development of a tool such as the hammer, and development techniques such as Ajax which allows web applications to communicate with a server, without interfering with the current state of a web page.

Seeing interaction design as a craft with movement as the material for design led me to consider approaches from anthropology where studies of human movement, arguably, are moving from *an observationist view of behaviour to a conception of body movement as dynamically embodied action* (Farnell 1999, p. 341) and to more participatory-based embodied approaches for data gathering and analysis. These participatory approaches in anthropology tend to emphasis the *how* of movement, rather than the *what* and *where*. That is, participatory approaches tend to focus and allow fuller understanding of an experience by focusing not just on how it looks (*the arm moved*), but also on how it might feel to do the movement or interact with technology (*how the movement is experienced*). Framing my research approach in terms of these considerations lets me ask questions about the nature of experience, the nature of craft, and the nature of practice in interaction design, and to develop an inquiry about movement, interaction design and kinaesthetic and proprioceptive aspects of interaction experiences.

3.3.1 Data Collection and Analysis

The second study employed an ethnographically inspired field study approach with the aim of developing an understanding of the lived experience of coming to know movement. I explored how practitioners learn to improvise, play and perform with movement in Pilates, yoga and Capoeira (a Afro-Brazilian acrobatic martial art).

Sixteen interviews with thirteen participants, practitioners and instructors, were conducted. These interviews were both video and audio recorded. In addition, participant observation was used to gather data for understanding the transformation of the lived body as movement skills were acquired. I also participated in classes in yoga, Pilates and Capoeria for the duration of the study. The interviews took place in Sydney, Australia over a two month period in May-June 2005. I also conducted four additional interviews, with a musician, two soccer players and a weightlifter. While these interviews are not reported in the thesis, they informed my thinking. This study was by no means a traditional ethnographic immersion, although it is heavily ethnographically inspired and borrows in its approach to collection, analysis and interpretation of data.

My assumption in the study was that people vary considerably in the extent to which they regularly reflect on their movement experiences; in the language of Polanyi (1983), I was trying to tap into or unlock *tacit* knowledge. Therefore, in designing the study, my challenges became to find ways of engaging the participants in movement experiences that might trigger reflections that would enable them to articulate these experiences, as well as finding ways of capturing data about the experiences. Semi structured interviews with *movement triggers* as an elicitation technique (Schensul et al.1999), collection of both verbal and bodily articulation of movement, and *engaged* participant observation were chosen to gather data for understanding the transformation of the lived body as skills were acquired. As stated by Brown et al. *As a method, ethnography rests considerably on craft and analytic know-how that comes from engaged practice* (2007, p. 412). To some extent, I also drew on methods from HCI, for example, Gaver et al.'s probes (1999), Paulos and Jenkins' interventionist techniques (2005) and Oulasvirta et al.'s bodystorming (2003), in the way in which these design researchers use different techniques for triggering reflection in study participants.

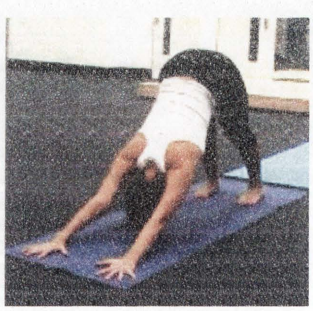
In the participant observation part of the study, I tried out movements demonstrated by interviewees etc, as well as attending classes in the interviewees' practices over a period of time before, during and after the time period in which the interviews took place. By combining participant observation and interviews conducted in the field, I tried to address the issue that

> *The distinction between what people do and what they say is also related to the fact that people often don't have access to inarticulated, tacit knowledge associated with certain activities.* (Blomberg et al. 1993, p. 130)

Kinaesthetic and proprioceptive experiences are part of our everyday lives. However, people are not always able to articulate accurately when asked to reflect and talk about these experiences. This supports the value of participating in the activities in addition to interviewing people about their activities and their experiences in these activities.

In my analysis, I was looking for articulations of the experience of learning, of performing movement, of what helped people learn, as well as of what aspects of instructions the participants focus on. I transcribed the interviews, viewed the videos multiple times and re-enacted movement both in training sessions and while writing up the study. As part of my later analysis, I also juxtaposed different understandings of movement, utilising different perspectives as a methodological tool for my analysis. See Table 3.1 for an example of the different descriptions and articulation of perspectives captured (I expand on the methodological aspects of this in section 3.6.2, and the analytical aspects in Chapter 5.)

Table 3.1: Downward-facing dog in yoga, Participant 2

What the body is doing	What it looks like	How it feels to do when I'm Doing it Right
The palms are positioned shoulder width apart with the fingers spread and the middle finger facing forward. The shoulder blades are worked flat on the back, the collarbones are broadened. While pressing the palms into the mat, the arms, side chest and waist are extending to lift the sitting bones to the ceiling. The heels are extended towards the floor while lifting evenly through the ankle, knees, thighs to work the legs straight. The head is encouraged to hang.		*In this pose the knowing that I'm doing it right means a feeling of energy flow, there is an ease in pose, you are not sweating, the body is not hard, and there is no pain and the effort is evenly distributed.*
Researcher's articulation of shape and spatial path	**Practitioner's bodily articulation**	**Practitioner's verbal articulation**

From the analysis of the participants' verbal and bodily articulations, and my own experiences and interpretations, I described the kinaesthetic and proprioceptive experiences of skilled movement as the recognition and achievement of the particular perception that accompanies a *fluent performance of effortless mastery*. The

experience of a fluid performance of movement is an experience of the perception of the body's interaction in the world, in terms of the kinaesthetic and proprioceptive senses as well as the other senses. Further, my findings from this study suggested that the knowing required and involved in doing core movements in Pilates, yoga and Capoeira (I focused on *neutral spine, downwards facing dog* and *Armada*, respectively) is a knowing *how*, and that this knowing is *felt* and achieved through moving. That is, the performance, as in the skilful doing, acting or performing of the practice, is the way to articulate this knowing. I also developed a continuum of knowing or a description of the nature of bodily knowing where I differentiate between *understanding* and *knowing* when knowing is constituted by doing. This distinction means that we might be able to bodily understand, but not yet perform, yet also perform without explicit bodily understanding. This relationship refers to the role our body plays in our meaning making that takes place in our ongoing movement dialogue within the particular circumstances in which we act, for example, neutral spine, downward facing down or Armada. The second study is described in detail in Chapter 5.

3.3.2 From Study II to Study III

From the second study, I described the *continuum of knowing*. Once a movement practitioner has reached a level of mastery, he or she not only does movement, but can improvise, play with and perform movement. I wished to develop my understanding about movement as a material for design further, and what (if anything) it could add to our understanding of the craft of interaction design. Hence, I decided to examine the part of the continuum where knowing is not only constituted by doing movement, but by *performing movement,* as it is in a professional movement practice by professional or trained movers. I distinguish this approach from studies that look at the use of movement in design practice by studying professional designers, who might be trained in design, but not necessarily trained as movers.

A second consideration contributed to the development of the third study. From my review of the literature on how movements are used in interaction with technology, I tentatively identified *tangibility, proximity dynamics* and *body schema* as sensitising principles potentially relevant to technology interaction enabled though movement. These notions became one focal point for the third study, and a link back to technology design. Furthermore, I continued to investigate experiential descriptions of

moving, one of the questions that arose out of the first study. As such, the first study, the second study and the literature came together to form the basis for the third study.

3.4 Study III: A Study of Professional Movers and Movement as a Material for Design

The third study aimed to explore what it means to perform movement practice as a professional mover, that is when working with movement as a material for design. Working with thirteen professional dancers and their director/choreographer at a dance company in Accra, Ghana, over a period of 4 months (February-May 2006), I observed and participated in the daily activities of the dance company, I carried out interviews with the dancers individually and as a group, and I led a number of sessions with the dancers.

3.4.1 Data Collection and Analysis

The study proceeded in a three stage process: developing a shared foundation, active engagement and gathering of insights generated. My time with the dancers was a combination of activities for bodily engagement with topics for discussion combined with individual interviews, group discussions, observation and participant observation; similar to the methods used in the previous studies. The activities were intended to explore movement and to orient the dancers to the issues I wanted to explore. We created choreographies with and around technology, we discussed and performed using the sensitising principles tangibility, proximity, dynamics and body schema, we discussed and performed how props influence dancing and choreographing, and we discussed issues such as bodily awareness, reflection, technology and movement. One example of the outcome of these activities is presented in Figure 3.3 (below). The aim in the activity that generated these choreographies was to work with recognisable features of movement such as shape, rhythm and direction. As a result there is a certain use and performance of space and time.

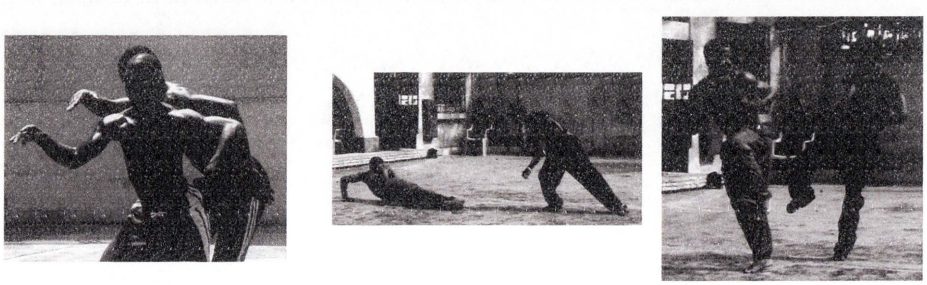


Figure 3.3: Performing shapes and producing and performing space and time

The methods used for data collection and analysis were carried over from the previous study for two reasons. First, because they seemed to have worked well in enabling the participants in the second study to access and make conscious their movement experiences and secondly, by keeping my methods consistent I believe I strengthened the rigour of my research. The exercises were also a way for me to articulate and share the insights I had reached at that point, and a way to engage the dancers in reflection about their materials - their bodies and the movements they could or might perform.

> *...ethnography often runs counter to common knowledge because it requires tapping into what people take for granted about their work, and thus, do not ordinarily discuss.* (Jordan and Dalal 2006, p. 368)

By engaging the dancers in exploration of and reflection about their materials and bodies, I tried to facilitate reflections about movement experiences and about movement practice. This allows the third study to focus on reflective practice and interaction design practice, as my overall perspective in this project is one of informing technology design. The outcome from this study is further understandings of movement practice, which, for a professional mover, is a coming together of skills, understanding and knowledge to recognise, perform, express, understand, appraise and create movement in space and time. This study is described in depth in Chapter 6, and further conceptualised in Chapter 7.

It should again be said that akin to the second study, this third study is by no means a traditional ethnographic immersion, although it was heavily ethnographically inspired and borrowed that field's approach to collection, analysis and interpretation of data. It is a *dip* into a particular setting that was entered with some specific ideas I wanted to explore, rather than a long-term immersion in a setting.

3.5 Summary of Research Design

I briefly summarise the focus of the three studies and relate the studies to theory and concept development below.

3.5.1 Studies and Study Focus

In developing my studies, I used methods and techniques from within the disciplines of HCI and design as well as other fields such as anthropology, dance and performing arts, human movement studies and somatic practices/therapy. The three resulting

studies of the *use* of technology enabled through movement of the body, the *experience* of moving and movement as a material for *design*, were carried out using audio, digital video and digital still photography in a series of interviews and sessions of participant observation. Methodologically the three studies had four main focal points: *movement performance, movement experience, HCI methods*, and movement practitioners with different levels of *movement expertise*. The three studies varied along these four axes. Note: the different intensity in the tone of grey indicate a weaker (pale grey) or greater role (dark grey) of a focal point in a study. See Figure 3.4 below.

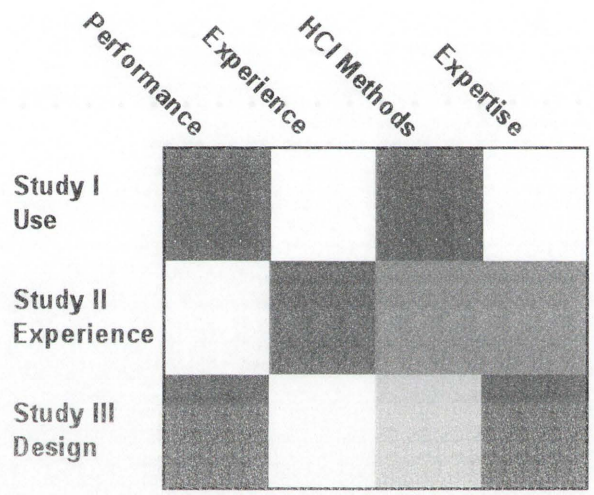


Figure 3.4: Summary of the three studies and study focus

The first study utilised *HCI methods* to the greatest extent, followed by Study II, which used similar methods for data gathering. Study III used methods that are less frequently found in HCI. The second study had the closest and most explicit focus on *movement experience*, while Study I and III both focused on the *performance of movement* though the movements were analysed differently. In Study III, I worked with the most *skilled movement practitioners* (professionals), followed by Study II, where the practitioners were all movement practitioners, but not all professionals. In Study I, movement expertise was not a factor in the analysis. Working along these intersections, I was able to come up with suggestions for future practices in interaction design.

3.5.2 Relating Studies to Theory and Concept Development

Figure 3.5 shows an overview of my research, illustrating the relationship between the empirical explorations described in this chapter, the theory on which it is based and the concept development that follows.

My phenomenological grounding influences the way I look at the theory about *human movement and experience* and *movement and experience in technology interaction*. Study I drew on theory from both these areas; the second study developed from Study I and it drew mainly on theory about *human movement and experience*, while in Study III, the first and the second study and theories from both areas came together to form the foundation.

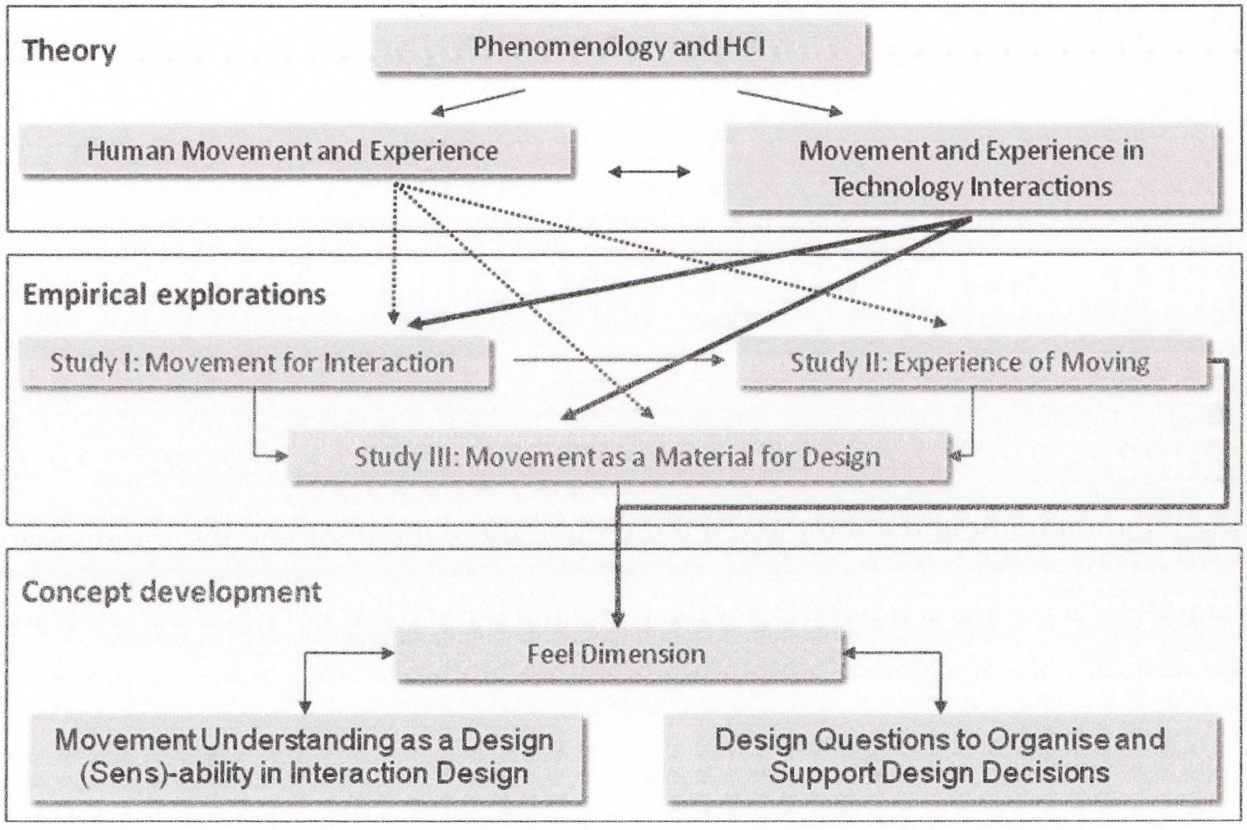


Figure 3.5: Relationship between the three studies, theory and concept development

The *feel dimension* of technology interaction, a conceptualisation of kinaesthetic and proprioceptive experiences of movement enabled technology interactions, is an outcome of the second study. Hence the heavy black line connecting the two in Figure 3.5 above. However, alongside movement understanding as a design (sens)-ability and the design questions, the feel dimension was further refined, reinforced and extended through the third study; the three concepts are presented in their entirety in Chapter 7.

3.6 Discussion and Reflection on the Methodological Approach

> *There is a difference between comprehending the project of phenomenology intellectually and understanding it "from the inside." We tend to get a certain satisfaction out of grasping at a conceptual or "theoretical" level the basic ideas of phenomenology, even though a real understanding of phenomenology can only be accomplished by "actively doing it."* (Manen 1997, p. 8, quotations in original)

Although I researched a number of areas searching for the appropriate theoretical foundation for my research, the methods used for gathering data remained the same throughout the three studies. A series of interviews and participant observation sessions were carried out using digital audio recording, digital video and digital still photography, note taking and journaling as aids for data gathering and recordkeeping. I became increasingly involved throughout the research, from being mainly an observer at the beginning of the first study, to close engagement in the second and close to immersion in the third study. This engagement affects the data gathering, the analysis and the generation of theory and concepts. As such, my role or the nature of my involvement becomes both *methodological* and *epistemological* significant. I address this by further describing and discussing the nature of my involvement and the issue of engaging with subjective experiences of movement in research. Subsequently, I try to address these issues by opening and presenting the different perspectives involved in the interpretations and analysis of what I observed and experienced.

3.6.1 Engaging with Subjective Experiences of Movement

Engagement with subjective experience of movement can be found in somatic practices such as yoga, the Feldenkrais method (developed by Feldenkrais, 1972), the Alexander technique (developed by Alexander, 1985) and many other activities. *Somatics* is a term coined by Hanna (1988) to label fields that were developing mind/body integration disciplines using the body as experienced from within. The practices suggest that knowing can be constructed through focused and attentive experiences of the body (Hanna 1988, Johnson 1995). In research, this approach has been adopted in several fields, such as anthropology, philosophy and dance. As a paradigm or methodological orientation, Csordas calls it *somatic modes of attention* (1993) and describes it as an *attending to and with one's body* (ibid, p. 138).

> *To attend to a bodily sensation is not to attend to the body as an isolated object, but to attend to the body's situation in the world. The sensation engages something in the world because the body is "always already in the world." Attention to a bodily sensation can thus become a mode of attending to the intersubjective milieu that give rise to that sensation. Thus, one is paying attention with one's body. Attending with one's eyes is really part of this same phenomenon, but we less often conceptualize visual attention as a "turning toward" than as a disembodied, beam-like "gaze." We tend to think of it as a cognitive function rather than as a bodily engagement.* (Csordas 1993, p. 138-139, emphasises in the original)

Csordas suggests that

> *A notion of somatic mode of attention broadens the field in which we can look for phenomena of perception and attention, and suggests that attending to one's body can tell us something about the world and others who surround us.* (Csordas 1993, p. 139)

He mentions dancing, making love and playing team sports as examples of situations where there is a somatic mode of attention to the position and movement of other peoples' bodies. Influenced by Dewey's (1934) pragmatic philosophy and the Feldenkrais method (among other influences), Shusterman (1997) developed *somaesthetics* as a philosophical method, which he describes as

> *...the critical, meliorative study of the experience and use of one's body as a locus of sensory-aesthetic appreciation (aisthesis) and creative self-fashioning.* (Shusterman 1999, p.302).

Shusterman was dissatisfied with the way philosophy was addressing issues of preoccupation with the body in the Western world. With somaesthetics, he wanted to provide a way for philosophy to deal with the somatic, not only reducing it to gender or racial difference. With somaesthetics he aimed for *...both a reconceptualization of the body and philosophy. The body is no longer a mere philosophical subject, but a philosophical agent*, he said (ibid, p. 267).

Shusterman is mentioned here as he forms the foundation for practical applications of these types of approaches in for example anthropology and dance. (e.g. Ness 1992 and Lowell Lewis 1995). Ness combined ethnography and choreography in studying the *sinulog*, a ritual dance performed in the Philippines. She says,

> *To fully comprehend what the act of performing a choreographed movement can mean ... - a person must have some idea of what performing any choreographed movement can mean at all. There must be some appreciation of how getting oneself physically through a choreographic moment can affect a human being, and how it can affect one's own cultural understanding.* (Ness, 1992, p. 2)

And she continues,

> *This is a kind of meaning different from that most historians, political scientists, economists and other social scientists have studied and valued, for it is meaning that develops in relation to essentially creative or* originative *figures of thought and action. It is meaning that must emerge from personal and subjective reflection, and in attuning to the moment-to-moment experience of being physically alive.* (ibid, p.3, emphasis in original)

While Lowell Lewis (1995), who worked at the intersection of anthropology and performance studies, studying *Capoeira*, says

> *I want to suggest that there is a significant difference between artists or practitioners whose main instrument is the body itself (and some extrinsic tool or tools) and other kinds of agents. What one does when learning a skill is to focus precisely on the mediating processes that link relatively embodied and relatively disembodied states. [...] During this process, experiences of the body in action become the focus of awareness, become foregrounded in a way that is unusual for most people most of the time. [...] However, I believe that body practitioners such as dancers, athletes, and actors in our world are in this intermediate mode more of the time than are others, and thus their world of embodiment are different from the norm.* (Lowell Lewis 1995, p. 229).

My reason for including Ness (1992) and Lowell Lewis (1995) is not to draw attention to the specifics of what they say about culture or learning, but to give the reader a sense of the attention to experiences of the body in their research. They both emphasise the heightened sense *of* and *for* movement, which can be attained by a person through focused engagement with movement.

The Nature of my Involvement

What I try to describe and illustrate here is that from the nature of my engagement and the way in which my involvement in my studies influences and informs my research, I speak from a similar place to Csordas, Ness and Lowell Lewis. In my interactions during this research, I was responding, interpreting and analysing information as a movement and interaction design practitioner. By considering movement in the light of somatic practices and as an investigative and exploratory practice in trying to access subjective experience of movement, I extend methods currently available in HCI. It also enables me to later discuss movement as a form of knowing.

I had no illusions nor intention of full participation in any of my settings. However, my observations and experiences were intertwined with the participants' articulations and demonstrations of their experiences of learning movements. My regular presence in the activities enabled an ongoing dialogue and collaborative process between the movement practitioners and myself (in Study II) and the dancers and myself (Study III) about movement and bodies that could define my role as an *apprentice*, a *collaborator*

and as a *catalyst* for reflection in relation to the participants in these studies. My combined experience in all of these roles shaped my understanding and contributed to how the studies were carried out, the analysis was conducted and the theories that are developed in Chapter 7.

Reflection is a part of the phenomenological method and therefore an important component of this research project. Many definitions of reflection exist. However, most agree that it is an active, conscious process that can be triggered when encountering unfamiliar or challenging situations. Schön (1987) identifies two types of reflection; *reflection-in-action* (thinking on your feet) and *reflection-on-action* (retrospective thinking). He suggests that reflection is used by practitioners when they encounter situations that are unique and to which they may not be able to apply theories or techniques learned previously. In this research, I tried to capture both the movement practitioners', dancers' and my own reflections. The reflection being explored can be described as *bodily reflection*. In the studies, I tried to access *reflection-in-action* through observation and participation, while *reflection-on-action* was attempted accessed and captured in interviews and other verbal articulation. This took place, for example, when talking with the practitioners and dancers during breaks or while watching others practice. Particularly for the third study, but also for the first two studies, my observations and recordings started out trying to capture as much information as possible. Later, I would focus on particular aspects directed either by the activity I was running or aspects that had caught my attention. This could be how different practitioners performed the same movement, the way a choreography used the available space, how lifts were used to create a sense of extension, a particular dancer and so forth. This approach was inspired by Jordan (1993) who among others, suggest a *person*, *place*, *object* or *process* focus for ethnographic observation.

For all three studies, the analysis was carried out by transcribing interviews, audio recordings and video footage, writing up notes and summarising observations. For the first and second study the footage was edited down[1], the clips were viewed multiple times and the movements taking place were re-enacted. Researchers (e.g. Schensul et al. 1999, Jordan and Henderson 1995), who have written on the use of video data in ethnography and ethnographically inspired research, stress the importance of repeated

[1] In the third study, I captured only digital still images, not video.

viewings in order to uncover and understand the issues being investigated. I see my repeat viewing of the video data, re-enactment, ongoing discussions with practitioners and ongoing involvement in the participants' activities as a similar approach, which allowed me the opportunity to check my analysis as it developed. In addition to the data collection techniques described above, I read technical literature about the movement disciplines, and I am still in conversations with both instructors and practitioners about experiences of learning, doing and performing movement in these disciplines. This provided me with additional background information from the communities of these practices, as well as the ability to discuss nuances of the disciplines that have revealed themselves to me as my analysis developed and I became a more experienced practitioner and researcher. So, the nature of my involvement in this research is such that I claim to study my participants' *experience*, their *movement* – what it looks like and their *experience of movement* - what it feels like to do, as well as *experience movement* myself. Hence I am studying *experience*, I am experienc*ing*, and I am becoming experienc*ed* in movement to inform my ability to reason about movement. The *experience*, experienc*ing*, and becoming experienc*ed* represent different perspectives of understanding movement.

3.6.2 The Possibilities of (Multiple) Perspectives

In Chapter 2, I suggested that human movement can be described from many perspectives. For my purposes, I described movement as subjective experience, as object and means, as a function or construct of the social, and as knowing and understanding. For example, technology *sees* human movement as object, and technology is fairly good at capturing movement, but not always as good at interpreting what movement means. In this section, I discuss how multiple perspectives were used to develop the account of my research and as an analytical tool in my analysis.

Several questions arise: when studying and describing movement for interaction with technology, which perspective do we adopt, that of the actor as in phenomenology, or that of the observer in biomechanics? Furthermore, does adopting either perspective yield the information necessary for our task at hand? In a paper discussing the phenomenology of embodiment and materiality of music in Capoeira, Downey (2002), refers to a similar quandary in trying to describe *what music sounds like?*

> *I fear that by presenting an objectified recording as "the music," I may seem to imply that the musical object alone determines musical experience, that when my audience hears mechanically reproduced sound event, they hear the same "thing" as the performers or listeners who produced that performance. The boldest audience members often throw this question back at me: "What exactly are we supposed to be hearing?"* (Downey, 2002, p. 487, quotations in original)

Both Downey and I are trying to work backwards from descriptions to perceptions of what something sounds like or feels like to do. Methodologically, this is perhaps problematic, although we both do this in an ongoing exchange between accounts of experiences and our own experiences of learning processes. Geertz addresses the issue of access into the experience of others by suggesting that what ethnographers are studying is not experience itself, but the structures through which experience occurs:

> *The ethnographer does not, and, in my opinion, largely cannot, perceive what his informants perceive. What he perceives, and that uncertainly enough, is what they perceive "with" – or "by means of," or "through". . . or whatever the word should be.* (Geertz 1983, p.58, ellipses in the original)

In this research I bring together different perspectives, I assumed an objective gaze and equipped with the vocabulary of Labanotation described movement in terms of anatomy. I studied movement being a mover myself. I observed movement as a questioning researcher in interaction design from the standpoint of technology design. I studied the role of movement as performance in a social setting, and I observed and interacted with the participants, the performers, choreographers and audience members who expressed their experiences to me. In addition, I reflected on the implications of transposing the movements taking place in one setting, e.g. the yoga school or dance studio to the street or board room.

See Table 3.2 (below) for an illustration of visually observable aspects of movement alongside attempts at capturing experience, the objective anatomical description, the objective visual recording and the participants' verbal descriptions of their experience. In Study II, I use these, the objective anatomical description, the objective visual recording and the participants' verbal descriptions of the participants' experiences as part of my analysis (in Study III, drawings). By juxtapositioning different understandings of movement, I use the different perspectives as a methodological tool for my analysis. This was an attempt to address Suchman's insight that *our ability to think about any design problem, and the quality of our thinking, depend to a large*

extent on the appropriateness of the representational resources that we can use in our thinking (1994, p. 1).

Table 3.2: Describing and recording movement

Objective - Description	Objective – Recording	Subjective – Description
Description of anatomy and physiology, which body part is moving, spatial path, shape, timing and dynamics of movement	Picture (or moving image) showing observable aspects of movement - what it looks like	Practitioner's descriptions of how a movement feels to do
Researcher's verbal articulation	Practitioner's bodily articulation	Practitioner's verbal articulation

By bringing together these different perspectives of the *perceiver* and the *perceived* in developing my concepts, interrelated with my own experience, I tried to go beyond objectifying movement *just* as recording or transcription and *just* relying on the experiential; in doing so, I drew on Merleau-Ponty's *reversibility*, which Robertson (2002) describes as,

> *Instead of conceptualising the perceiver and the perceived as opposite and exclusive terms, as is implicit in the use of the more familiar term reciprocity, he introduced the term reversibility to describe the relations between them. Reversibility requires the continual intertwining of the two aspects of embodiment, the body as an object in the world, that we perceive and others perceive, and the sentient body as it is lived by a particular person.* (Robertson 2002, p. 308)

This means that I, in this research, was involved not in a dichotomy as the *participant* or the *observer*, but as participant-observer

> *Observer ↔ Participant-Observer ↔ Participant*

It is from this position as a participant-observer that the generative work in this thesis emerged, exploring the relationship between the perceiver-perceived not through the visual as was developed by Robertson (1997a and 1997b), but from the perspective of the kinaesthetic and proprioceptive senses. See the grey columns in Figure 3.6 (below) for an illustration of this relationship.

Objective – Description	Objective – Recording	Subjective – Description	Subjective - Description
Description of anatomy and physiology, which body part is moving, spatial path, shape, timing and dynamics of movement	Picture (or moving image) showing observable aspects of movement - what it looks like	Participant-observation: Studying experience, experiencing, becoming experienced	Practitioner's descriptions of how a movement feels to do
Researcher's verbal articulation	Practitioner's bodily articulation	Researcher verbal articulation of the experiential	Practitioner's verbal articulation

Feel Dimension an articulation of the role our kinaesthetic and proprioceptive senses play in experiencing technology interactions from the point of view of people moving and acting.	Movement understanding as a design (sens)-ability in interaction design Design questions to organise and support design decisions
Perspective of mover	Perspective of designer of movement-enabled interaction

Figure 3.6: The researcher's position and relation to concept development

Consequently, when in Chapter 7, I discuss kinaesthetic and proprioceptive experience and designing, and I propose conceptualisations for technology design based in experiential accounts of experience, I suggest employing methods that enable designers to think about and around the body. This means also using methods that enable us to think *through* and *from* the body, and equip ourselves to design based on the understandings we generate. The methods must encourage intertwining and the development of a rich and subtle understanding of experience and awareness of both the people who might use the technology and the designer/researcher.

3.6.3 Studying Experience and Reliability and Validity

As method,

> *Ethnography is a discovery science, not a validating one.* (Whalen and Whalen in Jordan and Dalal 2006, p.6)

Phenomenology, as my chosen theoretical framework, is the philosophy of lived experience, and phenomenological research is the study of essences; it is about what is actually experienced in our everyday lives. In phenomenological research one tries to uncover and describe the essential meaning structures of lived experience. As a

method, phenomenology suggests how things should be approached, dealt with and understood. Working within a phenomenological tradition, a study of use, kinaesthetic and proprioceptive experiences, human movement and design, suggests setting up situations where essences can be intuited, grasped or understood by studying the particulars or instances as they are encountered in lived experience. It calls for empirical grounding in actual lived experience. For me, this means that what needs to be understood is the lived experience of people moving, using and designing technology. The understanding of action as a *situated activity* is another such theoretical commitment. Situated action, *...actions in the context of particular, concrete circumstances* (Suchman 1987, p. viii), must be studied by observing and experiencing actual use, rather than contrived examples or second hand reports. Writing about the use of reports of action, rather than direct observation/experience, Suchman argues:

> *One objective in studying situated action is to consider just those fleeting circumstances that our interpretations of actions systematically rely on, but which our accounts of action routinely ignore.* (Suchman 2007, p. 118)

Given that this research project has been carried out within a particular academic context, the issues of reliability and validity or their phenomenological equivalents should be mentioned. While in all three studies, I had data from interviews, audio and video recording and my participant observation, I was to a large extent asking my participants to communicate their experiences by verbalising. I devised the multifaceted approach, because I was doubtful that *just* interviews would enable me to gain a good understanding of the phenomena I was investigating. My assumption was that a verbal description of experience would be missing an important part of what constituted it. The knowing involved in carrying out a particular move in Pilates, yoga or Capoeira, is a type of knowing on its own and, as such, not something that can be made explicit and verbalised. A number of the participants contacted me after our interaction and mentioned that the issues brought up in the studies were issues they would not usually reflect on, but that the interview *got them thinking*. Nevertheless, verbal communication is a pervasive means of articulating and sharing, and therefore a natural place to start.

From a phenomenological perspective, it makes little sense to *measure* reliability separately from the experiences and understandings of the researcher. Therefore, I

have attempted to be as transparent as possible about the background to the studies, how the studies were conducted, how the experiences of the participants and the researcher are related, as well as the setting and context in which the interpretation of the data took place. This way I hope the research is open to scrutiny on *intersubjective corroboration*, meaning my research can not be *tested* in terms of repeatability of the procedure and findings, but as *interpretive possibilities* in the data (Seamon 2000, p. 171). This is where the ongoing relationship between my mode of inquiry, my claims about ways of knowing and my conceptualisation that is my own bodily understanding, interpretation and articulation comes into its own.

3.6.4 Ethics

I tried to keep issues of ethics at the forefront in this research, and carry it out in adherence with good research practices. As a doctoral candidate, my conduct is governed by formal procedures put in place by my university, that is, *ethics by procedure*, and as a researcher I'm obligated by my own ethical standards, which govern my responses in the different situations in which I find myself. I call this *ethics in action*. This personal ethics means upholding my personal integrity, including consideration for my (potential) participants, myself and the progress of my research, for example in situations where I had to make split second decisions about my conduct; about how far to go to try to recruit a desired study participant. Throughout the research, I tried to remain conscious of the fact that I was combining theories and methods from disparate areas by conducting my research in a way such that I did not detach these from the theoretical, methodological and ethical principles that informed their development. I tried to manage issues such as these by continuously reflecting on my perceptions, assumptions, behaviour, decision and decisions to not take action.

Formal issues of ethics were addressed in the preparation, submission and approval of the ethics application for this research by the University of Technology, Sydney's Ethics Committee. Ethics approval for this research was applied for and granted before the commencement of the first study. Approval number: UTS HREC 03/123, granted on Dec 19th, 2003. The ethics application addressed issues of privacy, storage, study sample, procedure, time commitment and possible side effects for the participants.

3.7 Conclusion

My aim in this chapter has been to make explicit the methodological approach taken in this research about kinaesthetic and proprioceptive aspects of interaction with technology. It was approached by addressing the notion of kinaesthetic and proprioceptive experiences in three studies in which I studied *use*, *experience* and *design,* that is the *use* of technology enabled though movement of the body, the *experience* of moving, and finally movement as a material for *design*. The studies were carried out in an iterative fashion, where each phase of the research was used to refine the next phase.

The empirical work included 34 participants directly involved in my studies, and many more indirect participants, encountered during classes for the second study or unknowingly observed as part of my ongoing observation of how people around the world move. The direct participants were encountered once, twice or numerous times during interviews and sessions of participant observation ranging from 45 minutes to four months. In the analysis, multiple perspectives were used both as a conceptual tool to aid the analysis, and to make explicit my role and close engagement as a participant observer in this research. Earlier in this chapter, I quoted Klooster and Overbeeke, who said,

> *We realize that theoretically describing this approach* [Choreography of interaction] *is a nearly impossible venture. In fact, only through movement, through practicing it, the idea can actually be grasped.* (Klooster and Overbeeke 2005, p.23)

Overall, my aim has been to develop and describe one possible methodological approach that could provide a theoretical contribution to extend our understanding of kinaesthetic and proprioceptive experiences as an experiential quality of interaction with technology. I have tried to make explicit my approach, not for the purposes of repeatability of procedure, but as Klooster and Overbeeke (ibid) also state in concluding their paper, I hope that my research will engender further discussion about the role of movement in design.

Chapter 4
Study I: Describing and Representing Movement for Interaction

The empirical work for his thesis is made up of three studies. This chapter reports on the first of these studies. It came out of a review of the literature that explored how current HCI research draws on the physicality of the user for input, for interaction and for interface control. Four frameworks and approaches drawn from areas relating to interaction, design and movement were identified as potential candidates that would allow investigation of the relationships between bodily actions and the corresponding responses from technology. These frameworks were used to analyse the findings of from a study of people playing two Sony® Eyetoy™ games.

> *... a moment of interaction is actually embedded in an entire gesture that determines its timing and feel...* (Benford et al. 2005, p.12)

During this research I conducted three studies; I studied *use*, *experience* and *design*, that is the *use* of technology enabled through movement of the body, the *experience* of moving, and finally movement as a material for *design*. In this first study, the focus is on the *use* of technology enabled through movement.

As mentioned in the Introduction, this first study was carried out in collaboration with another PhD candidate, Lian Loke. Outcomes from this study have been published at two conferences and in one journal publication, Larssen et al. 2004, Loke et al. 2005a and Loke et al. 2007, respectively.

4.1 Empirical Beginning – The Eyetoy™ study

In addition to the HCI literature on the use of movement in interaction with technology, a review of the available literature also took us through areas such as embodiment in HCI, movement studies, the use of dance notation in HCI and the use of sensors for gesture recognition. From these areas, four frameworks and approaches relating to interaction, design and movement were identified as potential candidates that would allow us to investigate the relationships between bodily actions and the corresponding responses from technology. The four frameworks were interaction analysis (Suchman 1987), two design frameworks (Benford et al. 2003 and Bellotti et al. 2002)[1] and movement analysis (Hutchinson 1977). These frameworks enabled us to start exploring ways of describing and representing the bodily movements enabling game play with two Sony® Eyetoy™ Playstation2® games, as well as other movements performed while playing. Suchman's (1987) framework for *interaction analysis* enabled us to see the communicative resources available in the interaction. The bodily movements used in the interaction were analysed using *Labanotation* (Hutchinson 1977), a system for analysing and recording movement, traditionally used in fields such as dance choreography, physical therapy and drama. The two design frameworks, Benford et al.'s *Expected, Sensed and Desired: A Framework for*

[1] Benford et al. published a revised version of their framework in Benford et al. 2005. We conducted this study in 2004 using the "old" framework. In this chapter I have updated the terminology to reflect the newest version of the framework.

Designing Sensing-based Interaction (2005), and Bellotti et al.'s *Making Sense of Sensing Systems: Five Questions for Designers and Researchers* (2002) allowed two different views of the relationships between the bodily movement and the technology.

4.1.1 The Study

In the study, we explored movement as input for human-computer interaction through a study of two Sony Playstation2® Eyetoy™ games. We used the Eyetoy™ games as prototypes of possible future systems that are based on human movement and computer vision. The Eyetoy™ game setup consists of a motion recognition camera that plugs into a Playstation2® game console and a TV or a projector. The Eyetoy™ games rely on movement as direct input to enable interaction, that is game play. A player has no direct physical contact with the technology, that is, there is no controller, joystick or similar to play the game. The games can be played using movements of any part of the body, but tend to be played mainly with movements of the torso and arms. The player's movements are used to drive the interaction by coinciding spatially and temporally with buttons and game events that form part of the gamescape. While playing, the player can see a projected image of his/her body in the middle of the screen, overlaid on the gamescape.

During game play, depending on the game context, only certain areas of the screen are deemed active (by the system) at any point in time. By active, we mean that a player's movements, *in relation to* particular areas of the screen, can be sensed by the camera and so registered as input. There is an optimal distance for motion recognition of the player, given by a certain calibrated distance from the camera. This is set at the beginning of the game, by the player standing so that his/her body fills an outlined figure on the screen.

We examined the twelve available Eyetoy™ games to identify the most suitable games for this study. Suitability, in this context, was defined by the range of movements that could be used within the game, as well as the game's learnability. Two games, Beat Freak and Kung Foo, were selected. Beat Freak (see Figure 4.1) requires the player to move his/her hand over a speaker in one of the four corners of the screen at the same time as a CD flies across the speaker. The CDs fly out from the centre of the screen and reach the centre of the speaker cone in time with the music. The active area for input in this game is the circular zone representing the cone of the

speaker. For a given event such as a CD flying out from the centre to the upper left corner, the target area becomes active for a specific time period in which the user's movement can be registered.

Figure 4.1: Beat Freak game

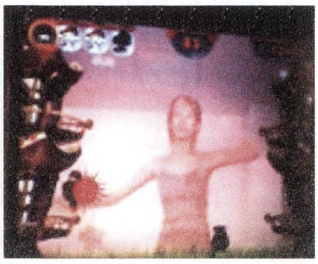


Figure 4.2: Kung Foo game

In Kung Foo (see Figure 4.2) the player has to strike Wonton's (the head enemy) henchmen by moving his/her limbs to intersect with moving images of the attackers. If the player misses and the attackers reach the middle of the screen, the player loses 'a life'. The henchmen appear randomly from pagodas positioned at three levels at the sides of the screen. Extra points are gained by breaking wooden boards and hitting Wonton himself when he appears. The active area for input is the area corresponding to any of the moving henchmen, Wonton, or the stationary wooden boards.

4.1.2 Participants

Eight participants, four female and four male, were recruited to play the two games. Four of these eight participants had already tried playing one or several of the Eyetoy™ games. Their prior experience in activities relating to the two games, for example, dance, martial arts, gymnastics and aerobics was limited, but three of the eight were active in other sports. Another three out of the eight found it generally challenging to learn physical movement and choreographies, while the remaining five found this fairly easy to do. The participants were between 21-50 years of age. Of these, there was one left-handed person and four wore prescription glasses. See Table 4.1 below for an overview.

Table 4.1: Study I participants

No	Age	Gender	Previous experience with Eyetoy™	Familiarity with arcade and computer games	Learning movement and choreography
Player 1	24	Male	None	Good	Challenging
Player 2	37	Male	Yes, but could not remember which game(s)	Expert	Challenging
Player 3	50	Female	Boxing, dancing, window washing games	Average	Challenging
Player 4	34	Female	None	Good	Fairly easy
Player 5	33	Male	None	Novice	Fairly easy
Player 6	21	Female	Dancing, boxing	Average	Fairly easy
Player 7	32	Male	None	Average	Fairly easy
Player 8	25	Female	Beat Freak	Novice	Fairly easy

Since our focus was not to investigate game play ability, but rather the movements used in the interaction, the interaction itself and the relations between the technology and bodily movements, we did not perceive the difference in previous Eyetoy™ experience to be an issue.

4.1.3 Study Setup and Data Gathering

The players were filmed from two angles. One view captured a projection of the player's mirror image on screen in the gamescape; the other view captured, from front-on, the player's full body whilst playing, see Figure 4.3 below. The two researchers were positioned behind each of the cameras.

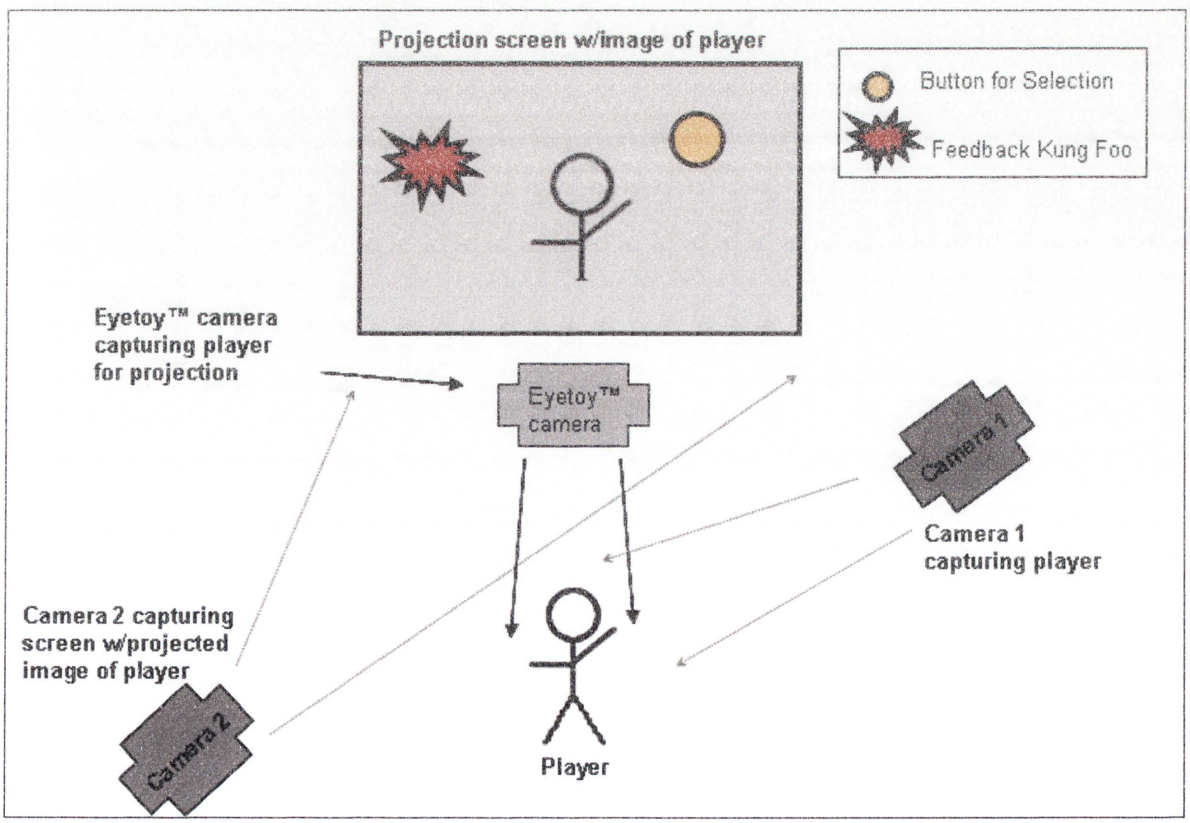


Figure 4.3: Setup for Study 1

To avoid injury, the players were warmed up through a series of light moves and stretches by an experienced aerobics and yoga instructor before playing. The players were then introduced to each game by working through the game's Help feature. Each player played each game twice on the *easy* level and once on the *medium* level of difficulty. Afterwards, the players were interviewed about their experience with the game and given a questionnaire with usability related questions.

Three of the eight players (Players 2, 5 and 8) were selected for initial analysis on the basis of variation between their movement styles. The variations consisted of flow, speed and the precision with which the movements were carried out. The actions and movements used for game play were identified from these three players, and then evaluated against the remaining five players. This enabled an iterative analysis of the actions and movements used to play Eyetoy™. During this process, the video recordings from both cameras were viewed multiple times by the researchers, individually and together, in order to determine:

- The actions taking place in each game; and
- The specific movements used to perform these actions.

4.1.4 Initial Observations

The two games studied (Figure 4.1 and Figure 4.2) engendered quite different movements. *Beat Freak* produced highly regular, repetitive, reaching movements of the arms to the high and low diagonals as dictated by the beat of the music. *Kung Foo* produced a variety of strong, fast movements in all lateral directions in space in accordance with game-initiated events. The *selection* action, performed in order to navigate the game's menu system consisted of reaching movements and a wave of the hand. Due to the selection button's positioning in the projection, this action was carried out with the right side of the body, as illustrated in Table 4.2 below.

Table 4.2: Selection action performed by Player 5

Start	Mid-reach	Extended reach and wave
		

We identified four basic actions for game play. These four actions were *selection* (for navigation), *strike moving object at fixed target* (the CDs in Beat Freak), *strike fixed target* (the wooden boards in Kung Foo) and *strike moving target* (the henchmen in Kung Foo). Each of these actions was performed with a variety of movements reflecting the individual player's movement style. For example, we observed the players using slashing, punching, slapping and swatting movements in order to intersect with the henchmen before reaching the middle of the screen. See Table 4.3.

Table 4.3: Game actions and characteristic player movements

Action	Description	Game	Movement
Selection	Navigation and selection of game choices and settings	Both	Wave
Strike moving object at fixed target	Coincide with object at target location	Beat Freak	Reach, flick
Strike fixed target	Strike as soon as object appears	Kung Foo	Slash, punch
Strike moving target	Strike as soon as object appears	Kung Foo	Slash, punch, slap, swat

Beat Freak and Kung Foo do not encourage people to move away from the spot calibrated at the beginning of the game, as this generally results in successful game actions not being registered by the technology. Most players stayed in one spot, moving only their arms and acting within the lateral plane, although two players did perform occasional kicks. Perhaps more experienced players would be more adventurous in how they moved their bodies in the space. We observed that most of the players at some point during game play did engage in experimentation into how their movements could result in a higher ratio of successful strikes. This was usually once they started to seem comfortable with the games. A common strategy involved

holding their arms further out to the periphery which was then closer to the point of interaction with the target event. Some people described this style of game play as cheating, most tired of the strategy, and reverted to a more natural posture with their arms closer to their upper body whilst readying for the next game event.

4.2 Extending the Analysis

The game actions, the movements used in the interaction, the interaction itself and the relationships between bodily actions and the corresponding responses from technology are the features that were analysed using the four frameworks (Suchman 1987, Bellotti et al. 2002, Benford et al. 2005, Hutchinson 1977). Suchman's (1987) framework revealed the communicative resources available for interaction between the players and the technology. Benford et al.'s (2005) framework, *Expected, Sensed and Desired: A Framework for Designing Sensing-based Interaction*, was developed to assist in the design of moveable, physical interfaces, such as mobile devices or interactive furniture. Bellotti et al. (2002) proposed a framework for the design of sensor-based systems, *Making Sense of Sensing Systems: Five Questions for Designers and Researchers* based on a model of human-computer interaction as human-human interaction. Finally, Labanotation (Hutchinson 1977) is a system of analysing and recording movement, traditionally used in fields such as dance choreography, physical therapy and drama. In the remainder of this section, each framework and approach is introduced and discussed in turn.

4.2.1 Interaction Analysis – Suchman

> *The starting premise is that interpreting the significance of action is an essentially collaborative achievement. Rather than depend upon reliable recognition of intent, mutual intelligibility turns on the availability of communicative resources to detect, remedy, and at times even exploit the inevitable uncertainties of action's significance.* (Suchman 1987, p.69)

Suchman's pioneering work on human interaction with technology claims that action is always situated and improvisatory in nature (1987). In her much quoted study of photocopy use, she draws on techniques from conversation analysis for human-human interaction and uses an *analytic framework* (1987, p.116) to emphasise the resources available for human-machine interaction. This framework incisively reveals the disparity in the communicative resources for interaction between *human* and *machine*.

We have taken Suchman's analytic framework and used it here to analyse the interaction between the player and the Eyetoy™ interface, for the two games chosen.

We adapted the framework to fit our particular context. The column labeled *Actions not available to the machine* has been split into two, to bring out the details of the movement description for the user's actions. The column labeled *Effects available to the user* has also been split into two, to clarify the game context in which specific actions are occurring. In the original framework there is a fourth column on the right-hand side, *Design rationale*, for the machine. This column was renamed to make clearer the aspects of the machine side of the interaction we wanted to highlight.

An example of a fragment of the interaction analysis for the Beat Freak game play by Player 8 is given in Table 4.4. The data is purposely laid out in the table (after Suchman, 1987) so that the columns labeled *Actions available to the machine* and *Effects available to the user* constitute the interface of the system that is available to both human and machine.

Table 4.4: Interaction analysis framework – Beat Freak 1st game play, Player 8

The User			The Machine	
Actions not available to the machine		Actions available to the machine	Effects available to the user	
User activity/action	Movement description	Via camera	Output: Visual display and audio	Game context
Awaiting start of game.	Ready position: Standing feet hip width apart, both hands held at navel, closed fist.	Calibrated image of user	Gamescape Visual text: Countdown	Game starts
Attempt to hit CD as it intersects speaker cone.	Reach out to upper front left with left arm, fingers spread.	(no machine input besides image of user)	CD emerges from centre and travels to upper left speaker.	Event – CD launched
Successful strike on the beat.	Left hand intersects speaker cone simultaneously with CD.	Motion detection over area representing upper left speaker cone as CD passes through it	Speaker vibrates and CD shrinks. Sound of cymbal clash.	Event - successful strike
Return to ready position.	Lower left arm to ready position.	(no machine input besides image of user)	Gamescape with animated characters dancing along	Pending next event
Waiting for next event, rhythmic sway to music.	Shifting weight side to side.	(no machine input besides image of user)	Gamescape with animated characters dancing along	Pending next event

The critical point here is that the machine has available only what is in the grey column of the table for interpretation of the interaction – and the human user has everything else! Laying out the interaction in this form makes clearly visible the perceptual asymmetry, between the human and the machine points of view, which is what Suchman wanted us to see in her original work. We can see that the player has

an exceptionally rich perception and interpretation of the action and game activity. The resources continually available to the user consist of the visual display, sound output, the game action and events - all of which are synthesised by the user to create a space in which to perform meaningful physical actions within the context of the game. As humans, we are able to create the necessary context for a satisfying experience, regardless of the sophistication of the technology. We create a world to inhabit and within which to perform movements as part of meaningful actions for interaction. The moment of interaction is embedded in a gestural phrase that is part of an overall activity that gives the movements their meaning and distinctive quality or as Benford et al. say *...a moment of interaction is actually embedded in an entire gesture that determines its timing and feel...*, (2005, p.12). For example, in the Beat Freak game the player reaches out to strike the flying CD as part of a rhythmic activity dictated by the beat of the music. In Kung Foo, the player strikes attacking henchmen as part of a martial arts fighting situation.

In contrast, the machine (in the grey column) has limited resources available for interpretation of the action. This is related to the choice of input technology for Eyetoy™ - a single camera provides motion detection of the player's movements within its frame of view. The machine perception is thus limited to motion detection, typically over a narrowly defined spatial area within a given time period, as directed by the context of a particular game event. For example, in Beat Freak, the machine detects motion only in the area corresponding to the speaker cone when the CD is passing through it. Likewise, in Kung Foo, the machine detects motion in the area(s) corresponding to the moving henchmen as they jump towards the centre of the screen. This particular technology implementation makes no attempt to track or recognise human movements - it simply detects motion.

The analytic framework derived from Suchman was valuable in two key ways. Firstly it *made clearly visible the resources available to the user and to the machine* for perception of action. Its prime function was to lay out the sequence of interaction and the interpretation of the interaction from both the human side and the machine side. Second, and most significantly in terms of understanding movement, we were able to *describe the movements as actions occurring in context*, without losing the situated and contextual aspects of the performed movements. For example, the player is

involved in an act of striking an attacking opponent in Kung Foo. The movements performed to effect this action, in a particular instance, took the form of the player moving his/her left arm to the lower left side, with a slashing quality. In between defensive strikes, the player was observed to perform readying or preparatory movements, such as shifting his/her weight from side to side. The richness of perception for the player is in sharp contrast to the machine's simplicity of perception of the action. This means that at the same time the machine is in no position to make assumption about player action, which allows freedom of expression in gameplay.

4.2.2 Design Framework – Benford et al.

The framework by Benford et al. (2005), *Expected, Sensed and Desired: A Framework for Designing Sensing-based Interaction*, was developed to assist in the design of moveable, physical interfaces, such as mobile devices or interactive furniture. This framework focuses on the often complex relationship between physical form and sensing technologies. The movements of the user in relation to the physical interface can be analysed and compared in terms of *expected*, *sensed* and *desired* movement properties:

Expected movements are those that users naturally perform. These are normally considered independent of any specific application. For the Eyetoy™ interface, a single motion detection camera and a display screen, expected movements include performing physical movement of any sort within the space dictated by the camera's frame of view.

Sensed movements are those that can be measured by a computer, given the available sensing technologies. For the Eyetoy™ interface, any player movements are sensed movements if they correspond spatially and temporally with the input region of the interface (governed by the camera's frame of view).

Desired movements are those required by a given application. For Eyetoy™ game play, waving a hand over a virtual game button to select a game setting, or striking sideways with the arm to hit a virtual game object, are desired movements.

Key aspects of this framework are that expected, sensed and desired movements only partially overlap and that mismatches between the categories can reveal potential problems, as well as opportunities to be exploited, in design solutions. The framework

can be related to existing taxonomies for input and input devices (e.g. Buxton 1986 and Jacob et al. 1994) that explore how to analyse sensed movements in relation to expected ones. Benford et al.'s focus on the overlaps and less expected or non-sensed movements differentiates this framework from these earlier ones.

For the purposes of our study of movement-based interaction, we applied the Benford et al. framework to an analysis of the Eyetoy™, solely with regard to the movements of the user. We disregarded the movements of the technology itself, since the Eyetoy™ interface is not intended to be a mobile technology and proper functioning relies on precise placement of the Eyetoy™ camera in relation to the screen and the player. The possible user interactions with the Eyetoy™ interface were studied using the expected and sensed categories of movement, without regard to the particular application (addressed by the desired category). Within this, we considered the less expected and non-sensed movements. The set of desired movements was evaluated for the specific application of the two Eyetoy™ games. Desired movements were initially taken to be those corresponding to successful actions performed during actual game play, and thus could also be classified as expected and sensed. In this case, the actions are to select game settings and game-specific movements. Finally, we considered the unsuccessful actions and other un-sensed movement as part of the set of desired movements that are part of normal game play.

The results of the analysis are summarised in a Venn diagram (Figure 4.4 below) that shows the combinations of movement categories (labeled A, B, C, D and E) that we found relevant to our study. The diagram shows that the movements that fall into combination A: expected, sensed and desired, are probably the movements intended for normal operation of the technology. These are movements that are sensed by the computer and make sense for normal game play. One example is of a successful action by the player of reaching to the upper diagonal to hit the CD as it intersects with the speaker cone. Sensed movements that players can make naturally, but breach game etiquette, such as unfair positioning of the body or limbs, fall into combination B: expected and sensed, but not desired. Movements not sensed by the computer but that make sense for game play fall into combination C: expected and desired, but not sensed. Examples include free and expressive movement, or moving outside the active sensing region of the screen to rest or swap players. D: Sensed, but not expected or

desired, accounts for sensed movements that may be interpreted as action by the computer, but were not made intentionally by the player. For example, the player accidentally intersects with a game object resulting in a lucky strike. The final combination E, sensed and desired, but not expected, would be movements that would be very difficult to carry out for most people or *unfortunate* movements, for example, where an object or another person passing in view of the camera is sensed and influences game play.

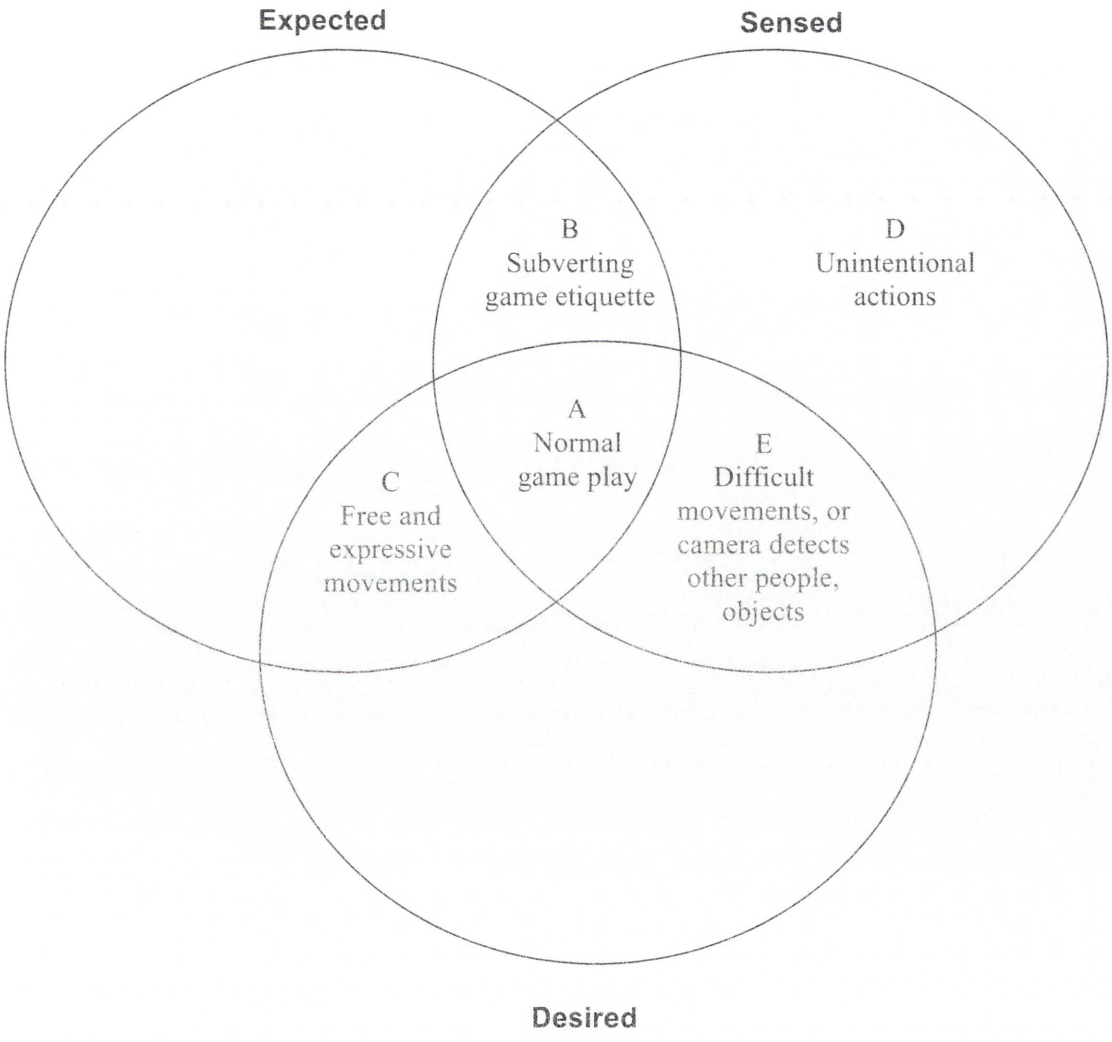


Figure 4.4: Combination of expected, sensed and desired movement

Movements outside these combinations were physically unlikely, technically not able to be sensed or undesirable for these particular games. The analysis clarified the relationship between the user, the technology (the form of the interface and devices) and the game application. It also suggested areas of potential redesign, such as

pausing the game by stepping outside the camera's frame of view. But also, perhaps more interestingly, the framework reveals the ways in which the user can subvert this relationship, through an examination of the non-sensed, less expected or less desired movements.

4.2.3 Design Framework – Bellotti et al.

Bellotti et al. (2002) proposed a framework for the design of sensor-based systems, *Making Sense of Sensing Systems: Five Questions for Designers and Researchers.* Their framework explores what happens when technology moves into the environment around us and the challenges this poses to the interaction between people and computers. The framework was informed by understandings of human-human interaction derived from the social sciences; human-computer interaction is viewed as *communication* between the user and technology and the concern is how to achieve *joint accomplishment* (Bellotti 2002, p. 416) in realising the interaction. The framework, in which the authors refer to Norman's seven stages of action (Norman 1998), is composed of a set of five issues that Bellotti et al. suggested could be posed as design considerations for designers of sensor-based systems:

- Address: Directing communication to a system;
- Attention: Establishing that the system is attending;
- Action: Defining what is to be done with the system;
- Alignment: Monitoring system response;
- Accident: Avoiding or recovering from errors or misunderstandings.

Drawing on comparisons with graphical user interfaces (GUIs), their subsequent exploration focuses on how to handle input and output issues in systems where the user interface might or might not be graphical.

We applied the Bellotti et al. framework to our analysis of the Eyetoy™ game play by considering how movement as input would hold as communication in this interaction. This was achieved by addressing the five questions posed by Bellotti et al.'s framework to the two Eyetoy™ games, Beat Freak and Kung Foo. The results of the analysis are presented in Table 4.5 below.

Table 4.5: Application of Bellotti et al.'s framework to Eyetoy™ game play

Questions	Eyetoy™ "Answers"
Address: How do I address one (or more) of many possible devices?	Only one device to address, but the player has to be positioned, i.e. calibrated with the system. Player chooses to step into position to initiate interaction, although interaction is possible when not optimally positioned. Interface elements designate areas to address. Motioning over the spot corresponding to the "button" or intersecting with game objects addresses the system. The system can also be addressed by other moving objects passing through sensing range, e.g. another person. No means of not addressing the system other than quitting the game. Pause not possible.
Attention: How do I know the system is ready and attending to my actions?	The player sees their image in the projection - this is a constant reminder of the system's attention. System attention is signalled with a request for command/input or game events. Feedback is in the form of text, images, animation, audio, e.g. animation of circle closing when "selected", and visual and audio feedback when intersecting successfully with the object.
Action: How do I effect a meaningful action, control its extent and possibly specify a target or targets for my action?	User interface with button and game objects that designate areas to effect action. The game directs the sequence of action. The player responds to events by moving limbs to intersect with the target. The player issues commands to change game settings by waving in a defined area in space - time, i.e. the interface specifies targets. Limited number of objects in the interface to manipulate to effect action.
Alignment: How do I know the system is doing (has done) the right thing?	Visual output on the screen in the form of text (e.g. score, stats) and graphics (e.g. smashed enemies). Audio output (e.g. cheering).
Accident: How do I avoid mistakes?	Not possible to undo an action during game play, given that this is a game, this would be cheating. A player can change selections only by using "cancel" which takes the player "back" one step. A mistake in terms of game play would be failure to intersect with an object, resulting in loss of a life, a lower score or the end of the game. Unintentionally intersecting with game objects during a game, resulting in a lucky strike with visual and audio feedback, but no disadvantage in the form of lost points.

The use of this framework enabled us to focus on the input and output mechanisms of the Eyetoy™ interface. Since the Eyetoy™ operates with a GUI-like display, some of the challenges that Bellotti et al. set out to tackle are solved as they would be in a conventional GUI. The questions of Address, Attention, Action and Alignment, address the traditional concerns of user interaction of knowing when and how to initiate action, and of receiving adequate confirmation of this action from the machine. The Eyetoy™ interface provides a visual display of the gamescape with a mirror

projection of the player inserted. The game controls the sequence of events. Thus the player is directed by the game as to when it is appropriate to interact through physical movements. Confirmation of the player's actions is given through changes to the visual display and sound effects. The question of Accident (How do I avoid mistakes?) revealed one of the differences in designing for traditional task-oriented interactions and more novel forms of interaction such as games. The Eyetoy™ games are designed to test and develop a player's physical skill. A mistake in a game, such as a missed strike, is a normal occurrence in game play and would typically result in a loss of points. Accidentally intersecting with an attacking henchman in Kung Foo could be considered a mistake, albeit a lucky one.

4.2.4 Movement Analysis – Labanotation

Labanotation is a system of analysing and recording movement, originally devised by Rudolf Laban in the 1920s and further developed by Hutchinson and others at the Dance Notation Bureau, New York (Laban 1971, Bartenieff and Lewis 1980, Hutchinson 1977). It continues to be used in fields traditionally associated with the physical body, such as dance choreography, physical therapy and drama. Labanotation can be used for analysis, choreography and exploration of all forms of human movement; it has also been applied in anthropology and industrial production.

Labanotation is a symbolic notation, related to music notation, where symbols for body movements are written on a vertical *body* staff. The symbols represent change; that is, movement. The staff is divided into columns for different body parts - support (typically the legs and the feet), leg gestures, body, arms and head. Movements are understood as either steps or gestures. A step is a movement that involves a transfer of weight. A gesture is a movement of a part of the body that does not involve a transfer of weight. There are three essential forms of movement description in Labanotation - *effort-shape, structural* and *motif*[2] (e.g. Laban 1971, Hutchinson 1977, Laban 1988 and Newlove 1993). (A example of Labanotation is provided in Figure 4.7 below.)

Effort-Shape describes the more qualitative and expressive aspects of movement and the inner attitude of the mover. For example, in dance choreography, this form of

[2] *Motif* is the simplest form of description and describes the salient feature of a movement or its motivation. It is a shorthand way of depicting just the essential aspects of the movement within a specific context. For example, it might just describe the steps taken in ballroom dancing or walking without representing any other aspects of the movement. The Motif descriptions were not used in this research.

description conveys the aesthetic, emotional and expressive qualities of the dance, not just where the feet are. Effort (or the energy content) of a movement is described in dimensions of Weight, Space, Time and Flow; together with how a person engages with or resists each dimension. Each dimension is represented by two polarities: Weight (Light/Strong), Space (Direct/Indirect), Time (Sudden/Sustained) and Flow (Bound/Free). There are eight basic Effort actions derived from the dimensions of Weight, Space and Time. A diagram of the basic Effort actions is illustrated as an Effort cube, otherwise known as The Dynamosphere (Newlove 1993), in Figure 4.5. For example, a Glide, which is Light in Weight, Direct in Space and Sustained (i.e., slow) in Time is represented by the top, back, left corner of the cube in Figure 4.5. A specific example of a movement with an Effort of Glide is ironing a delicate fabric. This type of Effort exhibits a delicacy in relation to Weight. In contrast, ironing out the creases with a firm pressure has an Effort of Press, which is strong in relation to the dimension of Weight (see the bottom, back, left corner of the cube in Figure 4.5. Figure 4.6 illustrates the same relationships, but in Figure 4.6 *shape* has also been added.

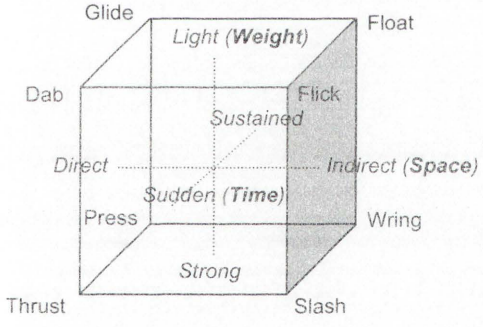


Figure 4.5: Effort cube

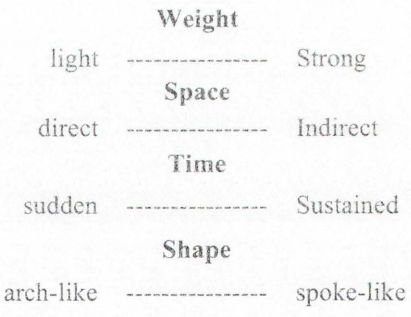


Figure 4.6: Continuum of effort-shape qualities

Shape describes the spatial shaping of form – growing, shrinking or carving patterns in space. The spatial intent of a movement determines the particular spatial shape that is produced as the movement unfolds. For example, the action of pulling a fishing net out of the water has a spatial intent that is directed along a radial line from the centre of the body to the periphery where the hands hold the net. The related spatial shape of the body is one that expands and contracts along the path dictated by the spatial intent as the person repeatedly pulls the net in towards the body (Bartenieff and Lewis 1980).

Structural provides the fullest and most specific description of movement in clearly defined and measurable terms: *the body and its parts* (which part of the body is moving), *space* (direction, level, distance, degree of motion), *time* (metre and duration) and *dynamics* (quality or texture, e.g. strong, heavy, elastic, accented, emphasised). The motivation for the movement can come from various sources: directional destination, motion, anatomical change, visual design, relationship, centre of weight and balance, dynamics, and rhythmic pattern. The Structural description is mostly concerned with directional destination as the motivation for movement; that is, where is the body going, where is the movement aimed at in space. In my studies I used only a small set of the descriptive forms of Labanotation; specifically directional destination, relationship (to virtual and physical objects), and dynamics (expressive quality) in terms of Effort. This is because of the particular forms of movement people used when playing Eyetoy™. But I do not wish to imply that other kinds of systems would not exploit more of the options available within Labanotation.

Other work in HCI using Labanotion and Laban's theory of movement falls into two main categories – recognition and simulation of movement. Badler and Smoliar (1979) used Labanotation for some of the most extensive and early work on simulating movement as part of computer animation. This has been continued with the development of the EMOTE model – a 3D character animation system that incorporates other elements of Laban's theory in order to produce simulated movement that is more natural and expressive (Chi et al. 2000). Further examples include animation systems for visualising dance choreography from written notation scores, such as Life Forms, NUDES and Virtual Ballet Dancer (Neagle et al. 2003). Aspects of Laban's theory are also being used in attempts to extract emotive qualities from human movement. Examples include computerised motion recognition systems such as EyesWeb, a system that recognises gesture and affect from dance movement (Camurri et al. 2000 and 2003); the design of gestures for affective input (Fagerberg et al. 2002); and the gestural semantics of caress (Schiphorst and Fels 2001). Most of this work focuses on the representation of human or human-like movement within the computer.

Analysis

The aim of this analysis was to investigate how Labanotation might be used for describing movement-based interaction with technology. We used Labanotation and

its system of movement analysis to analyse and transcribe the movements of individual players interacting with the two Eyetoy™ games. The game actions with corresponding movements identified for game play in Table 4.3 (above) were: Selection – *Wave*; Strike moving object at fixed target - *Reach, flick*; Strike fixed target – *Slash, punch*; and Strike moving target - *Slash, punch, slap, swat*. These movements were further examined to determine the specific types of movements used to perform them. The initial movements identified for game play (in *italics*) were further checked and performed with the games to ensure that they were effective for interaction. We eventually settled on a set of seven characteristic movements (see Table 4.6).

Table 4.6: Characteristic movements of game play

Movement	Description	Example
Reach	To extend the hand toward an object or destination.	Stretching up for the biscuit tin
Wave	To move the hand or arm to and fro repeatedly.	Waving goodbye
Slap	To hit something quickly with an open hand.	Thigh slapping
Swat	To hit hard and abruptly.	Swatting flies
Slash	To swing the arm quickly and freely through space.	Cutting through grass with a scythe
Punch	To strike an object with a closed fist with force.	Boxing
Flick	To deliver a light, sharp, quickly retracted blow.	Flicking away a piece of dust on one's coat

For each of the game actions, we transcribed a selection of player movements into movement scripts using the Structural form of Labanotation. The expressive quality of the movement was analysed using the *Effort* description in terms of the player's relationship to weight, space and time. The process of notating was done by each researcher individually before arriving at an agreed form for each player's movements. This involved a reflective cycle of revisiting the video data and re-enacting the observed and notated movements for a practical and embodied understanding of Laban's theory (after Newlove 1993), while refining our transcription. One of the virtues of transcribing the movements into Labanotation was that it forced a certain rigour upon our practice of movement analysis as we had to agree upon the movements, actions and the transcribed form in order to have a common understanding of the analysed movements. This required us to re-examine

and observe more closely the recorded movements and the motivations for those movements.

Movement Description

Next we present a detailed explanation of one of the four game actions - *Strike Moving Object at Fixed Target* in Beat Freak. This example was chosen because it efficiently demonstrates our application of Labanotation in this study. In order to capture the context of interaction in which these actions were performed, we augmented the movement transcriptions with computer interface elements depicting the screen and significant game event trajectories. Labanotation allows for reference to other people, objects, music and spatial environment, and can easily be extended to describe a person's relationship to virtual or computerised events, objects and environment.

Before describing the notated movements, an understanding of the model of the body and principles of movement used in Labanotation is required. This model is based on the mechanics of the skeleton and the different degrees of freedom of the various joints and limbs. For example, the arm is connected to the body at the shoulder with a ball and socket joint. This type of joint dictates the available paths of movement of the arm. For arm gestures, the spatial directions and levels originate at the base of the limb, namely the shoulder. The free end, the hand, is at the extremity of the limb. For the arms, a spatial level of High is above the shoulder, Middle is at shoulder height, and Low is below the shoulder. When notating, a *normal carriage* of the body is understood as a person standing erect with feet hip-width apart and arms held relaxed by the side of the body, unless specified otherwise in the starting position. For our purposes here, we have deviated from the standard Laban convention for the normal position of the feet being in ballet first position. Instead, for our context we are assuming a more natural position with the feet about hip width apart. The symbols on the body staff below the double line represent the starting position of the body. Any movement is then described as a change from this starting position.

For the *Strike Moving Object at Fixed Target* action, the notated movements for Player 2 are presented in Figure 4.7 below. We have extended the diagram by augmenting it with symbols for game events occurring on the screen. This allows us to depict the point of interaction between the movements of the player and the events

and input mechanism of the interface. We suggest that Figure 4.7 is read with reference to the guidance on *how to read the diagram* provided below.

How to read the diagram: The structural form of Labanotation is read from the bottom to top, with time in the vertical axis. Time can be split into measures (rows in the diagram), just as in musical scores. We have numbered each measure to facilitate explanation. The vertical staff represents the body, the centreline being the centreline of the body, the right hand columns represent the right side of the body and similarly for the left. The columns are used for main parts of the body, such as S - Support, and A - Arm; for example, movements of the arms are written in the *A* column. Symbols for indicating direction and level of movement in space can be combined and placed in the columns associated with the major body parts. Timing and duration of movement are indicated by the position and length of the symbol. A column without a symbol implies that no movement is taking place. A wide range of symbols is available to give more detailed information; for example, the degree of contraction of the hand. See the legend to the right of Figure 4.7 for symbols used in the transcription.

The contextualised movement transcription for player 2's *Strike Moving Object at Fixed Target* action is presented in Figure 4.7 below.

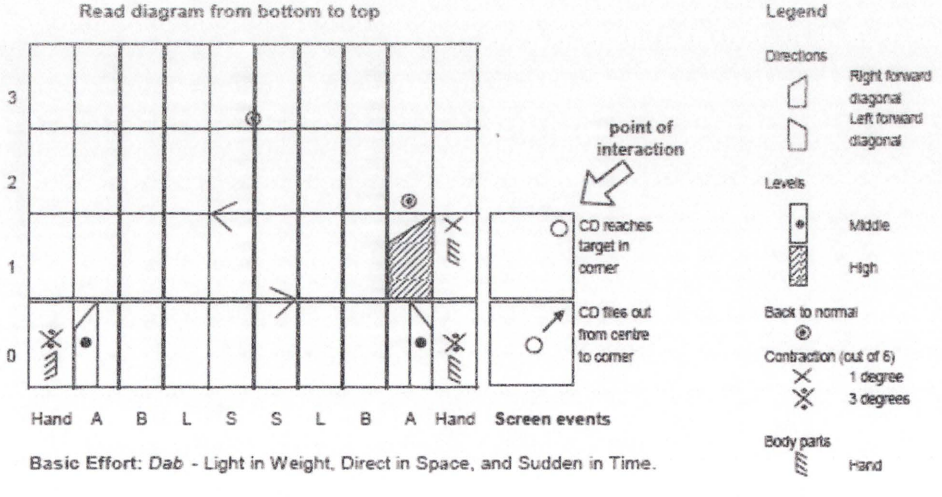


Figure 4.7: Movement transcript for Player 2 Beat Freak game

Figure 4.7 shows, in row 0, the player in a starting position with both arms bent at the elbow (the position of the lower arm is indicated by the placement of the symbol in

the outer half of the A - Arm column), the fists lightly closed (indicated by contraction of the hand) and held just in front of the navel, and the weight evenly distributed on both feet, feet about hip width apart. We have indicated the game events alongside the body staff - here a circle representing a flying CD is displayed emerging from the centre of the screen and moving towards the upper right corner of the screen. In the first row (measure 1), the player reaches to the right upper front with the right arm; the hand opening as the arm is fully extended. The player shifts the weight to the right (indicated by the caret symbol > in the S - Support column) as the right arm extends. The point of interaction occurs when the arm is fully extended to the upper right at the same time as the CD reaches the upper right speaker cone on the screen. Then in measure 2, as the player lowers the right arm to the starting position (indicated by the *back to normal* symbol), the weight is shifted to the left and then in measure 3, the player returns to a centre. We have taken a liberty with the use of the *back to normal* symbol and redefined it to indicate a return to the starting position for that body part, rather than the usual convention of the normal carriage, in order to simplify a problematic transcription.

The Effort description for Player 2 in Beat Freak is a *Dab*; a Labanotation category that is Light in Weight, Direct in Space, and Sudden in Time. The types of Effort identified for each game action resonated with the typical physical action associated with that game. Typical physical actions for Beat Freak would be lightly and quickly reaching to a point in space and retracting - these would tend to exhibit Dab-like efforts. We observed that all the players exerted the same Effort characteristic of Dab for the Strike Moving Object at Fixed Target action in Beat Freak. Similarly, common Effort characteristics across players were identified for the Kung Foo game actions (Thrust or Slash for the Strike Fixed Target and Strike Moving Target actions). The types of Effort identified for each game action resonated with the typical physical action associated with that game. In the Beat Freak game, the player reaches out to strike the flying CD at a known point in space as part of a rhythmic activity dictated by the beat of the music. Typical physical actions would be lightly and quickly reaching to a point in space and retracting - these would tend to exhibit a Dab Effort action. In the Kung Foo game, the player strikes attacking henchmen or breaks wooden boards as part of a martial arts fighting situation. Physical actions that express some degree of force, speed and directedness would be typical and would tend to

exhibit a Thrust Effort action (Strong in Weight, Direct in Space, and Sudden in Time). Sometimes players performed physical actions with an Effort of Slash that indicated some spatial uncertainty or imprecision by the player. In the Kung Foo game the point of interaction was less predictable than in the Beat Freak game, as the player is confronted with a swarm of attacking henchmen. The Effort of the observed movements in Kung Foo varied predominantly in the players' relationship to Space.

Functional and Performed Movement

For each of the actions, a comparison of the notated movements across the players was made to identify areas of similarity and difference. From this comparison, for each action we extracted the essential features of the movements required for the functioning of the interface from the player's perspective - we termed these *functional* movements. For a given game action, the functional movement represents the essential properties or the general form of the movement required for effective operation of the interface. A functional movement (or sequence of movements) will be performed by different people in individually characteristic ways, but should nonetheless achieve the same effect (for example, hitting a CD in Beat Freak to score points). *Performed* movement thus describes the actual, distinctive movements produced by particular bodies. These variations in individual performance of physical actions can be described in Labanotation. For example, the player is involved in an act of striking an attacking opponent in Kung Foo. The movements performed to achieve this action, in a particular instance, took the form of the player moving his left arm to the lower left side, with a slashing quality. In between defensive strikes, the player was observed to perform readying or preparatory movements, such as shifting his weight from side to side. All of this detailed description of the actual movements can be represented in Labanotation. However this may result in a design representation that is unwieldy and obscures the relevant aspects of the interaction to be modelled. Relevance is, of course, dictated by the particular application under design. The choice of how to notate the movement depends upon the context and aspects to be emphasised in the recording. What may be more fruitful is to identify and represent the relevant properties of the movements as they occur in the flow of interaction and at the point of interaction. The *functional movement script*, augmented with computer interface elements, is intended to play this role, as it provides an overview of the interaction sequence with the movements of the player as the central focus.

Primarily, Labanotation gave us a language and vocabulary for describing or talking about human movement, with the moving body as the central focus. It provided us with a systematic approach for observing and describing the moving body in space and time. Some of the value of using such a system of movement analysis and notation lies in the doing, in the work of transcribing, as it forced us to perform rigorous observation of bodily movements and to understand how these movements related to the context of interaction. For an even more extensive description of the application of Labanotation to the analysis and design of movement-based interaction, see Loke et al. 2005a.

4.3 Discussion and Reflection

There are two parts to the outcomes from this study; firstly each of the frameworks and approaches yielded different insights and useful perspectives that can inform the design of both movement- and sensor-based interaction. Secondly, the study enabled me to recognise the absence of first person descriptions and representations of the interaction experience that could elucidate aspects of kinaesthetic and proprioceptive experiences of the interaction. In addition, the nature of the understanding involved in carrying out the analysis in this study, particularly transcribing movements into Labanotation, seemed important and relevant to technology design and the study of technology use, but is one that is not widely explored and articulated in HCI literature. As such the study helped me identify what direction my research should take next in order to come closer to answering my question about kinaesthetic and proprioceptive experiences as an experiential quality in technology design and the study of technology use.

4.3.1 Understanding Movement for Interaction Design

Given their different origins, each of the four frameworks and approaches allowed us to examine the interaction between the player and the game technology in quite distinctive ways. Suchman's analytic framework exposed the inherent asymmetry in the relationship between the player and the technology in terms of the resources available to both sides for interpretation of the interaction. It enabled a rich and coherent picture of the player's activity within which s/he performed bodily movements for meaningful interaction. We were able to describe the movements as actions occurring in context, without losing the situated and contextual aspects of the performed movements. At the same time, from the technology's point of view, the

framework helped to pinpoint and explore the possible options for detection and interpretation of the player's action, given the sensing technology of single-camera computer vision implemented in the Eyetoy™ interface.

The Benford et al. framework helped to clarify the relationship between the player's movements and actions and the sensing technology used in the Eyetoy™ interface. The expected, sensed and desired categories, and the combinations and permutations of them, proved very useful for exploring possibilities for meaningful action through movement. The framework showed what is possible for the user through an examination of the less expected, non-sensed and less desired categories. For example, thinking in terms of expected and desired, but not sensed movements, allows for movements that are free and expressive and it allows for periods of rest. It also encourages consideration of the ideal movements for the interaction. Basing design on these movement categories can influence the choice of sensor, rather than limiting the movements of the user to fit within the capabilities of a given sensor.

The strength of Bellotti et al.'s framework was in the questioning of the five fundamental stages of human-computer interaction, following the model of human-computer interaction as a dialogue. Through this, we formed a clear understanding of the input and output mechanisms of the interface, and the corresponding relationship between player action and machine response and confirmation. One contention arising from our application of the Bellotti et al. framework, which treats interaction between people and technology as a dialogue, is viewing movement as communication. It may not be the appropriate metaphor for the Eyetoy™ games, as raised by Rogers and Muller (2006) in their *Stop Making Sense* framework that looks at using sensor technologies for user activities that are exploratory, playful or reflective in nature. The Eyetoy™ interface can be located somewhere between traditional GUI interfaces with discrete controls and interactive spaces with diffuse sensor input, as it replaces a more traditional joystick, mouse, or keyboard control with sensing of bodily movements through single-camera computer vision. Here the user actions are physical actions that correspond to physical actions within the game itself.

Labanotation and its system of movement analysis was the sole approach that focused specifically on the moving body. In this study we attempted to investigate how Laban's system of movement analysis and notation could be used in the design of

movement-based interaction with technology. The movement transcriptions in Labanotation of player actions contained visual - graphical representation of the interaction with the movements of the human body as the central focus. Extending the movement transcriptions to include aspects of the interface, provided a way of representing movement that retains its reference to actual, lived movement as performed through interaction with the Eyetoy™ interface.

4.3.2 Towards Developing a Deeper Understanding of Movement for Interaction

Understanding movement from the perspectives offered by the four frameworks and approaches that we examined in this study, is a step towards technology design and the study of technology use that take into account human agency produced by our embodied capacities to meaningfully engage with technology through our moving bodies.

Experiential Descriptions

The four frameworks and approaches, by themselves or taken together, do not explicitly address my overall research question *"how can kinaesthetic and proprioceptive experiences as an experiential quality be accounted for in technology design and the study of technology use.* I did not yet have personal descriptions of the kinaesthetic and proprioceptive experiences of the interaction. Conducting this study, as well as the reading I had done up to that point in my research, left me with questions as to whether there might be additional aspects to the description of interactive experiences enabled by the moving body. One crucial encounter was a body of anthropology literature, where there are ongoing discussions as to whether Labanotation is a subjective or objective (first-person vs. observer's) account of movement (see e.g. Farnell 1996). Further, although our study addressed the movements used in the interaction, the interaction itself and the relations between the technology and bodily movements used, it seemed to lack experiential descriptions and representations from the people playing the games, that is, the people who were performing the movements that enabled the interactions.

One of the questions that drove my research forward from this point was, if there were additional aspects about subjective experience of movement to the description of movement that we were not able to address with the frameworks and approaches we used in the first study, what might these additional aspects be, and how could this

issue be addressed? My commitment to understanding interaction experiences as starting points for a study of technology design and use, raised the question as to whether there is more to *understanding movement for interaction* than was uncovered in this study, and, if so, how could we better understand this issue?

Nature of Understanding and Knowing

As researchers, we were observers during the data gathering stage of this study. During the analysis phase we became participant observers by engaging in the same activities our participants had carried out during data gathering. Working with Labanotation to notate the particulars of the movements used when playing Eyetoy™ required us to re-examine and closely observe the movements we had recorded (and the motivations for those movements). The usefulness, or rather necessity, of moving when transcribing the movements enabling game play became increasingly apparent to me over time. Our moving and re-enacting would take the form of replaying the games, repeating and copying the movements we were watching on our digital video recording, and performing movements from the transcriptions to ensure that what we had transcribed would actually result in successful game play. Concurrently the fields of interaction design and design research saw the development of several design approaches that advocated explicit and focused bodily involvement by designers as part of the design process, for example Schiphorst and Andersen 2004, Djajadiningrat et al. 2007, Hummels et al. 2007, Jensen 2007 and Moen 2007. Describing their approach Hummels et al. said:

> *If one truly likes to design for movement-based interaction, one has to be an expert in movement, not just theoretically, by imagination or on paper, but by doing and experiencing while designing.* (2007, p.677)

Common to these approaches was a focus on designing the interaction itself, preceding the design of form and appearance. The understanding and skills involved in carrying out the analysis in our study, particularly transcribing movements into Labanotation, and the activities in these emerging approaches seemed important and relevant to technology design and the study of use. Although, the number of examples of these types of approaches was increasing, the *nature of* this understanding and skills as a competency in interaction design practice seemed not widely explored or articulated in the HCI literature. These insights led me to believe that my research questions could also be investigated from an additional viewpoint, that of trying to

understand the kinaesthetic and proprioceptive experiences epistemologically, that is through the nature of the understanding and knowing involved in competency in movement.

The considerations outlined above came together to form the impetus for the second study. Two topics crystallised for this next inquiry, the first to find ways to access experiential descriptions of moving, and second to explore the nature of experiential bodily knowing and understanding generated through experiences of the moving body. I framed this next study as an investigation of the coming to know of bodily skill and, from there, to suggest what this could mean as a type of understanding and knowing in interaction design practice.

4.4 Conclusion

> *The design challenge illustrates the importance of seeing the users as the creators of their own worlds, and that what an action means depends on the intentions of the user.* (Svanæs 2001, p. 397)

This chapter has reported on a study carried out by analysing movements and relationships between movements and technology produced in interaction with a computer game, the Eyetoy™. Four different frameworks and approaches were applied as they highlighted different aspects of movement used in the interaction, the interaction itself, as well as ways of evaluating these. From this study I proceed to explore how to access and more fully understand, interaction experiences, particularly subjective experiences such as kinaesthetic and proprioceptive experiences, as starting points for technology design and further study of use.

Chapter 5
Study II: The Nature of Kinaesthetic and Proprioceptive Experiences: A Study of Understanding and Knowing

In this thesis, I argue for including considerations of kinaesthetic and proprioceptive experiences in technology design and the study of technology use. This chapter present the results from my second study, where I studied the lived experience of coming to know movements in Pilates, yoga and Capoeira in order to learn how movement practitioners in these disciplines describe *fluency* or *effortless mastery*.

> *When I do it well it has got this really nice flow...feels like a spring* (Participant 9, Capoeira describing the spinning kick, Armada com Martelo)
>
> *Consciousness is being-towards-the-thing through the intermediary of the body. A movement is learned when the body has understood it, that is, when it has incorporated it into its 'world', and to move one's body is to aim at things through it; it is to allow oneself to respond to their call, which is made upon it independently of any representation.* (Merleau-Ponty 1962, pp. 159-161)

The focus for the second study in this research is the *experience* of moving. The experience of moving is explored in three different movement disciplines, Pilates, yoga and Capoeira, with varying degrees of focus on awareness in movement. From studying movement practitioners in these different disciplines, I obtain experiential descriptions of movement as well as come to understandings of the nature of experiential knowing. In the study I also explore the impact objects or props, have on the experience of moving.

As already stated, becoming a skilled mover is analogous to becoming skilled in a *craft*, for example, knitting, boatbuilding, or programming. The term craft indicates skilful, as in fluent and effortless handling and interaction with materials and tools; it means a person develops the ability not only to do the movement required to carry out an activity, but also to perform, improvise and play with movement. In relation to interaction design, using the term craft addresses the connections between perception and skill in studying and developing understanding in design. Both movement disciplines and craft develop through improvisation and skilful interaction by skilled practitioners that push the edges of the current rules and styles of a discipline.

Two main themes emerged from the data generated in this second study: the participants' articulation of *how it feels to move when I'm doing it right* and *how it feels to move when I'm not doing it right*. The findings, derived from audio and video recorded interviews are presented through quotes, descriptions, pictures and interpretations of the participants, as well as my own movement experiences. The organising principles for the presentation of the findings from this study are the two research questions for the second study:

i) What is the experience of moving; and

ii) What is the nature of experiential bodily knowing and understanding generated through experiences of the moving body?

The first question is addressed in this chapter; it also serves as an intermediate abstraction for addressing the second question in Study III, Chapter 6. I further address both questions in Chapter 7, where I discuss the nature of this type of knowing and make some suggestions about the applicability of the concept for technology design and the study of technology use.

5.1 The Study: Participants, Movement Disciplines and Analysis

Potential participants were approached either via email or in person, and the objectives of the study were explained. Interested parties were then recruited on the spot or a follow up email was sent with further information and an invitation to an interview session. Participants were primed with an outline of the questions and the general procedure a few days in advance. Thirteen participants were recruited for the study; eight female and five male, ranging from 24 to 58 years in age. The distribution of participants to activities was 6 capoeiristas, 4 Pilates practitioners and 3 yoga practitioners. Sixteen interviews were conducted and recorded using both video and audio[1]. All practitioners were interviewed once, three practitioners, one from each discipline were interviewed a second time together with their instructor.

The participants had been active in their disciplines from a few months up to 30 years. The length and involvement of the participants' background in these disciplines varied, some had been or were involved in many physical activities simultaneously. While others had been involved in individual activities in the past and were now only participating in the one about which they were interviewed for this study. Table 5.1 gives an overview of the study participants' age, gender and physical activities. The column *Activity* lists the activity they were interviewed about in this study, and the table also includes a summary of their involvement in other physical activities.

[1] The videocamera was positioned so that the activities could be captured without the researcher having to control the camera. The audio recording was used to ensure good audio quality and as a backup in case the video failed.

Table 5.1: Study II participants

No	Age	Gender	Activity	Current and previous physical activities
1	28	F	Capoeira	Yoga, weights, Pilates
2	30	F	Iyengar yoga	Swimming
3	51	F	Pilates	Walking, meditating
4	28	F	Pilates	Yoga, tennis, hockey, touch rugby
5	47	F	Pilates	Aerobics, running, spinning, weights, netball, softball
6	24	M	Capoeira	Soccer, surfing, rugby league, cricket, basketball
7	40	M	Iyengar yoga	Persian war dance (related to Dervish dance), football, rugby, surfing, biking
8	41	M	Hatha Yoga	Cycling, swimming,
9	32	F	Capoeira	Bike riding for transport (not exercise), rollerblading, netball, sprinting
10	26	M	Capoeira	Traditional dance, marching band, Tai chi, badminton, cricket
11	28	F	Capoeira	Synchronised swimming, school sports
12	28	M	Capoeira	Indoor climbing, roller hockey, squash, swimming, Kung Fu
13	58	F	Pilates	Ballet

The way the participants described their experiences with the different activities and their body in these activities suggested different kinds of relationships towards movement and their bodies. This was reflected in the language they used when describing the experiences of their bodies and engagement with their bodies. For example, the activities were labelled as *reflective, meditative, ballistic, explorative, fun, joy, rigorous, contemplative not decorative, fluid* and *non-engaging* (that is the activity was described as interesting, but more as a mental activity than a *bodied* activity). Motivating factors for engaging in ongoing physical activity were socialising, interest in the activity, learning, challenge, health and well-being.

I now introduce core aspects of each the three movement practices, Pilates, yoga and Capoeira along with the setting in which they are usually performed.

5.1.1 Pilates and the Pilates Studio

Pilates is a form of training that focuses on trunk stabilisation for posture alignment, re-education of the body for functional movement and recruitment patterns[2] and fine motor control (Gallagher and Kryzanowska 2000, Pilates and Miller 2000). Pilates uses equipment to aid the practitioner in performing certain types of exercises. The primary equipment used in Pilates is the Reformer and Cadillac. These two pieces of equipment shape the execution of many of the core exercises in Pilates. The Reformer and Cadillac consist of various adjustable parts that provide resistance and/or

[2] "Recruitment pattern" means to engage the anatomically most correct muscle or muscle group when carrying out a movement or sequence of movements.

assistance to varying degrees in exercises for the core abdominal muscles, spinal flexibility and the shoulders in order to strengthen and stretch the body. This is achieved through restricting or aiding movement in certain directions for a full range of movement in different exercises. Exercises on the Reformer are often carried out on a gliding platform; the challenge is to keep the platform moving while maintaining stability in the core of the body. Other pieces of equipment are balls, pillows, straps and wedges. An important aspect of Pilates is an emphasis not only on the performance of movement, but on how the rest of the body behaves while the movement is being performed. Pilates aims to empower people to manage their own bodies in everyday life.

In Pilates, one can take part in a *mat class* or a *studio session*. In a mat class, a group of up to 20 people carries out exercises led by an instructor. This is similar to an aerobics class; there is usually little equipment in these sessions, except maybe a strap. Pilates training in a studio is usually performed under closer supervision, either one-on-one with the instructor, or in small groups of up to four practitioners at a time. The Pilates studio is dominated by the larger equipment, the Reformer and the Cadillac, and mirrors covering most of the free walls. The interviews and participant observation for this research took place in several different Pilates studios; both in individual sessions with the equipment mentioned above and in mat classes.

5.1.2 Yoga and the Yoga School

The overall aims of yoga are about balance and unity of mind, body and spirit, and more about spiritual wellbeing than physical activity. Yoga is also seen as a process of self-transformation, where the mind is engaged to develop awareness of and transform one's physical and mental state. An inward focus and awareness of one's own body is encouraged, emerging as manifested in an increased awareness of self, one's own movement, and one's own mental state. The teachings of yoga also provide guidelines for how to live a meaningful and purposeful life (Iyengar 2001). The body, in the form of the various postures, is used as a tool to achieve this. In this research project I am interested in the practice of the physical postures, Ananas, specifically the *experience* of the practice of the physical postures.

In the Iyengar tradition, there is an emphasis on alignment in each pose, and poses tend to be held static for a long period, while in, for example, Astanga yoga, the focus

is more on a flowing sequence of poses and conscious breathing. The Iyengar tradition introduced the use of props; blankets, blocks, bolsters, straps, pillows, chairs and ropes are now widely used in Iyengar and other forms of yoga. The purpose of the objects is to assist in attaining ideal alignment in the poses, even if the body is not yet flexible and/or strong enough.

The aim for a yoga practitioner is to practise regularly, usually alone. However, many yoga practitioners regularly attend classes to get corrections and adjustments in addition to their personal practice; others attend classes as their sole form of practice. In yoga class, people are usually uniformly spread out in a room facing the instructor at the front of the room. Depending on the style of yoga, the teacher will name the pose in Sanskrit and/or English (or other languages) and then deliver very detailed instructions addressing each body part and the feel of the pose, or the instructions might be limited to the name of the pose or set of poses for the practitioner to perform. There are a number of different poses; they can be categorised as variations of standing poses, seated poses, inversions, arm balances and restorative poses. From these positions the practitioner goes into a variety of poses by bending or stretching legs and arms, and twisting the torso or bending it backward or forward. Alongside the postures, there are instructions for ways of breathing (Pranayama and Bandha) and meditation as part of a yoga practice.

A yoga class can be very quiet, with the teacher's voice as the only sound, or it can be accompanied by music or lively discussions with questions and chatting among the practitioners. Yoga schools tend not to have mirrors, because beginners especially, tend to focus externally on their outward form and pay less attention to how their body is feeling. Mirrors are sometimes used to make more experienced students aware of specific aspects of their practice.

5.1.3 Capoeria and the Capoeira Academy

Capoeria is an Afro-Brazilian acrobatic martial art game combining dance, martial arts movements, acrobatics and rituals. The game is *played* in a dance-fight by two capoeiristas (players) with the remaining capoeiristas forming a circle, the *Roda*, while singing and playing the *Berimbau*, a bow instrument, the *pandeiro*, a type of hand frame drum, and sometimes other instruments. In the *Roda* the two capoeiristas try to outsmart, trick or dazzle (this is called *malicia*, meaning the art of deceiving

one's opponent and tricking them into a compromising position) each other while demonstrating flair and mastery of movement. The rhythm of the music determines the rhythm of the game played. Objects used in Capoeria are the uniform, the music, the instruments and the other capoeiristas.

There are different styles of Capoeira (Capoeira Brasil-Sydney online, Capoeira Brasil Los Angeles online, International Capoeira Angola Foundation online, Wikipedia online);

- *Regional* emphasises the fighting aspects of the game with speed and martial arts moves with acrobatics and balances as important elements;
- *Capoeira Angola* is slower with balances and moves low to the ground, with an emphasis on the grace and beauty of the movement; and
- Capoeria Contemporanea, is, as the name indicates, a modern form of Capoeria, it blends elements from both Regional and Angola.

The movements in Capoeira are a combination of circular and straight kicks, escapes, sweeps, takedowns, and acrobatic moves. Most moves radiate out from the base movement *Ginga*, which means *rocking back and forth*. The Ginga can also be used when transitioning from one move to another. Variations on the Ginga include moving the torso and the rest of the body forward, back or to the side to avoid a kick or to create opportunities to attack. Capoeira can be an exciting spectator sport, and it is not uncommon to encounter Capoeira Academies conducting training sessions in local parks.

5.1.4 The Choice of Disciplines

The objective of this study was not to come to new understandings of the movement disciplines, Pilates, yoga and Capoeira per se, but to study the kinaesthetic and proprioceptive experiences of effortless mastery when moving. As such, a number of different activities could have been chosen for this study. Pilates, yoga and Capoeira were chosen for the reasons below.

Each of these movement disciplines brings about different ranges of movement. There are differences in the extent to which the whole body versus parts of the body are engaged, and the speed of the movements and the movement quality considered

appropriate for each discipline differ. Pilates, yoga and Capoeira are also activities with some (though to varying degrees) degree of bodily *contemplation*, that is, the extent to which there is deliberate use or encouragement to direct attention inwards as part of the practice. In both Pilates and yoga, an inward focus and increased awareness of one's own body is encouraged, in order to empower people to manage their bodies.

In yoga and Pilates, the learning and performance of the practice is the same, although one might practise an easier or simplified version of an exercise and move on to more challenging versions of the same exercise later. In Capoeira, there are two different *modes*; the basics of the moves are taught in session where the capoeiristas form rows while facing the front of the room. Usually the more experienced capoeiristas take up the positions towards the front, so the less experienced can observe and be given additional help. The instructor sometimes performs the movements facing the class (so if the practitioner looks at the instructor s/he will be performing the mirror image), sometimes with their back to the class, and sometimes they just observe. Thus it is helpful to have a more experienced player in front! People at the same level, indicated by a system of coloured cords (belts), train together, practising half and full moves. The honing and actual performance (the training manifests into games) of the moves takes place in the *Roda*, the circle of the capoeiristas. A consequence of this is that when one performs a movement in Capoeira, one does this for explicit external recognition to a much larger extent than Pilates or yoga.

> *There is definitely a performative aspect* [to Capoeira], *moves are practised solely to mesmerise, to show off and fun to do.* (Participants 6, Capoeira)

Though there are supposedly yoga competitions, where participants compete to perform the most beautiful Asanas, this is not seen as a major part of the spirit of yoga as understood in this research.

As there are different aims for the movements in the different disciplines, there are different purposes for the objects used. Pilates and yoga are thought of as activities with objects or *props*, but Capoeria is usually not. The props used in Capoeria, the music, instruments, uniform, the other capoeiristas, are integral to the game as they are necessary to establish the *Roda* as both the *space* and *event* for the movements to have their meaning (for performance) and for the game (Downey 2002).

Pilates and yoga have a somewhat similar focus on increasing awareness of one's own body. The way props are used in these activities is meant to support and enable awareness of intended effects on the body. The difference in use and purpose of props was also part of the reason these movement practices were chosen. I wished to explore whether the way objects are used in activities with bodily awareness would be perceived experientially as different from, for example, tennis rackets, and golf clubs or soccer balls. The fact that I was able to negotiate access to and time with a number of practitioners in these particular activities was also a deciding factor.

5.1.5 The Study and the Analysis

In this study, I was interested in data that would give prominence to experience and awareness of the body itself, that is, the lived experience of a fluent kinaesthetic and proprioceptive experience according to the moving, perceiving body. For this phenomenological investigation, I ask the question *what does it feel like?* and secondly, *what is it about kinaesthetic and proprioceptive fluency or effortless mastery that gives these experiences significance in terms of HCI and interaction design?*

The study employed an ethnographically inspired field study approach. The sixteen interviews with thirteen participants (practitioners and instructors) were conducted over a two month period in May-June 2005. During the interviews, I also tried out movements demonstrated by my participants. My participation in yoga is ongoing, while dedicated participation and observation of yoga, Pilates and Capoeria for this study took place in April-July 2005. The interviews were both video and audio recorded; in addition observation and participant observation were used to gather data for understanding the transformation of the lived body.

Procedure

The interview sessions lasted for about 45 – 90 minutes. The participants were first given time to go through their usual warm-up routine to prevent injury, and asked questions about their different physical activities, level of experience in each, what keeps them motivated to continue and so forth.

In the core part of the interview, the participants were asked to demonstrate 2-3 movements from their discipline, and then asked to teach me 1-2 of these movements. I asked questions related to the movements they were demonstrating and teaching, and

the participants were asked to answer verbally and encouraged to accompany their description with physical demonstrations. Instructors were asked a similar list of questions, and were also asked about the relationship between their own experiences as movers and how they give instructions, and what aspects of movement they emphasise in their instructions, for example, the way it should look, the way it should feel, where a practitioner should feel it and so on. (See Appendix A for my guide sheet of questions for the interviews). All the participants answered the same questions, but depending on how an interview unfolded, the questions were asked in an order appropriate for the particular interview.

In developing my overall interview approach, I used elicitation techniques such as critical/memorable events and objects, and recall of a specific time, to assist participants to recall and to elicit information about movement, props, past learning experiences, performance and other aspects of their movement practice that is not usually front of mind for most people. This method of encouraging the participants to perform movements as part of the interview is inspired by ethnographic methods (see e.g. Schensul et al. 1999). Also, by asking the participants to teach me movements as part of the interview session, I was able to see how the description of the experience of the movement compared with the teaching of it. For the participants that were interviewed a second time with their instructor, I was interested in how the descriptions correlated (or not).

During the interview sessions, I was with the participant on the floor, mostly in front of the camera engaging in the proceedings by asking questions, observing and learning movement. I also trialled a more distant *behind the camera* approach. However, it was found that the engagement between the participants and myself was far better when I left the camera behind and got on the floor. For the part of the interview where I tried out the movements demonstrated by the interviewees, it should be said that I participated to the best of my abilities. However, this meant that some times the complete or correct execution of the movements that my participants were teaching me was beyond the limits of my (cap)abilities due to lack of strength or flexibility, or due to injury or fear, for example, certain yoga poses requiring extensive flexibility or seriously acrobatic moves in Capoeira.

My participation in classes in these activities was an attempt at getting both a better theoretical and experiential understanding of what my participants were describing. When attending classes during the study, I participated as a regular practitioner, possibly paying extra attention to the movements my participants had taught me. The combination of methods was seen as a way of probing the questions from different angles.

Analysis

The intertwining of the participants' articulations and demonstrations of their experiences of learning movements with my observations and experiences are important in this study, both in the choices of methods and in the analysis of the data. My initial idea was to conduct observational studies of different activities combined with a few interviews. As I was planning the study, it became clear that I would not gain access to the places I wished if I was just going to be observing and filming. I also came to realise that kinaesthetic and proprioceptive experiences are not front of mind for most people. To obtain the information I was after, I had to become a participant myself. This meant that this study became a study about *experiencing movement* as well as about *movement practice*, *experience*, *movement* and *experience of movement*.

In my analysis of the data, I transcribed the interviews, reviewed my notes, viewed the videos multiple times and re-enacted movements both in training sessions and while writing up the study in our research laboratory. As stated in Chapter 3, Methods, the repeat viewings were motivated by researchers such as Schensul et al. 1999 and Jordan and Henderson 1995. who emphasise the importance of repeated viewings in order to uncover and understand issues being investigated. This approach allowed me the opportunity to obtain further perspectives on the analysis as well as to refine and check my analysis.

In the remainder of this chapter, I present the findings that emerged from the analysis. The aim is to describe felt qualities of movement experiences and observations in order to understand the characteristics and conditions of the constituents of the experience of the lived body, and the various relationships involved. The different descriptions and articulation of the kinaesthetic and proprioceptive experiences as presented here should be seen as continuously interlinked aspects of a holistic

experience. All the elements together make up the lived experience. The splitting up of the constituents of the experience is artificial, but it is helpful for the communication of the experiences in this thesis.

5.2 Findings: Felt Qualities of Movement Experiences

In order to achieve the *fluent kinaesthetic and proprioceptive experience of effortless mastery*, one must first come to know how to move. So, in a discipline, the fundamental challenge becomes to master *knowing how to move* in the different situations in which one finds oneself as a practitioner in that discipline. This could be mastering knowing how to hit a backhand in tennis, or knowing how to move the computer mouse to draw a box in a drawing program. For the reader of this thesis - you might choose to explore this by reading through the example provided in Physical Exploration 5.1 below, or alternatively, engage with it by carrying out the activity.

Physical Exploration 5.1: Activity II - exploring effortless mastery

> Think back to a time you observed someone unfamiliar with a computer mouse.
>
> Think back to your own first attempts at using a mouse in comparison with your current mastery.

From the point of view of kinaesthetic and proprioceptive experiences, a movement practitioner has to learn to recognise and understand *how it feels to do a movement right*. There is a particular set of perceptions accompanying a correct performance (including feedback provided through the other senses as well as from the equipment involved), and the practitioner has to learn to recognise that *this is how it feels to do it right*. The practitioner must then learn how to achieve that particular feeling, with her or his particular body in that setting. For the three disciplines studied here, it means knowing how it feels to do *neutral spine* in Pilates, *downward-facing dog* in yoga and the *Armada* in Capoeria – each of these movements are core to their discipline.

In Chapter 2, I outlined three different ways of approaching the understanding of movement and experience: movement as *object*, as *subjective* and as *knowing*. In the sections 5.2.2 and 5.2.3 below, I use these three perspectives to present the participants' descriptions of their movement experiences. Using the *objective* perspective, I present the anatomical description of the spatial and temporal aspects

alongside a photo of what the movement looks like, that is the bodily articulation as well as the view of sensor technology in a technology interaction. The description of the *subjective* perspective is present as a verbal articulation of *knowing*, that is *how it feels when I'm doing it right*.

This presentation and analysis of the data builds on the theoretical work I described in Chapter 3 (section 3.6.2), *The Possibilities of (Multiple) Perspectives*. Presenting the data in this way, with the practitioner's articulations next to two different observer's perspectives, was used initially as an analytic tool. Later, I recognised the conceptual significance of this difference in articulations from, among others, Suchman's work (1987). I discuss the experiential aspects of the experience here. For a discussion of the theoretical issues about multiple perspectives I refer to the Methods chapter (Chapter 3). However before delving into this I give an account of the different ways the participants would describe their movement experiences.

5.2.1 Descriptions of Movement Experiences

Based on the participants' descriptions of their movement experiences, I extracted three levels of experiential descriptions of movement. Movements were described in *measurable* terms, for example as descriptions of the *spatial* path and *temporal* aspects of moving a leg from one point to another. Then there are descriptions of movement experience, which incorporates descriptions of *dynamic* aspects of movement, such as balance. Finally, there is the *fluent movement experience*, which the participants generally described using metaphors. In fluent kinaesthetic and proprioceptive experiences, the *spatial* and *temporal* aspects of a pose or movement matter, but so does the way in which it is executed (*dynamic*) and how it feels to do (*metaphorical*). Table 5.2 below shows an overview of verbal articulations the thirteen participants used. Below the table I show some examples of how the participants used these articulations in their descriptions of their movement experiences.

Table 5.2: Felt qualities of movement experiences

Level of Experiential Description	Category: Example
Movement experience described in *measurable* terms, i.e. spatial and temporal	Spatial: Direction, height, distance and degree of motion of body parts, parts of the body most involved in the movement Temporal: Duration, speed and slowness, rhythm of movement
Movement experience described with *dynamic* aspects	Dynamic: Stability, balance, extension, flexibility, expression, momentum in a pose or a movement, and the coming together of control and function.
Fluent movement experience described with *metaphors*	Metaphor: Grace, flow, sound, touch, ability to relate to oneself, floating on air, clean, crisp, not rigid, beautiful, space-time, alignment is balance, awareness, no sweating, "the right" breathing, like a soccer kick, more round

The practitioners would use *measurable* descriptions of experiences of moving, for example, in terms of *space*, *time* and *dynamics*. Sometimes a combination of a measurable aspect, *height*, with a dynamic quality, *balance*, was used

> *It is really a balance thing: when you come back you are totally in place, and the kick is a really good kick. There is balance and height and the arms are where they need to be* (Participant 1, Capoeira)

Speed, slowness and maintaining the momentum can be part of the way a movement is carried out, and they are all important for a good performance. Speed can create momentum that can help *carry* the practitioner through a movement, for example,

> *...in Capoeira you eventually need to move so fast that the body has to take over, the movements are too fast for the mind to keep up.* (Participant 9, Capoeria)

versus the slowness of yoga as emphasised by Participant 8.

> *..for me the goal when I do yoga is meditation and awareness in stillness...* (Participant 8, Hatha yoga)

Participant 7, an Iyengar yoga practitioner who also practices a Persian war dance (related to Dervish dance) corroborated this point when describing how when dancing he is sometimes required to move different body parts at different metre very very quickly.

> *When your head, hands and legs all move at different metre, you have to rely on your body to remember.* (Participant 7)

In addition metaphorical imagery was used,

> *When I do it well it has got this really nice flow...feels like a spring.* (Participant 9, Capoeira)

Participant 6, who has earned a Capoeira nickname meaning *water* for his smooth and fluid style of play, said

> *...it's like floating on air* (Participant 6, Capoeira)

Others used almost existential articulations, such as

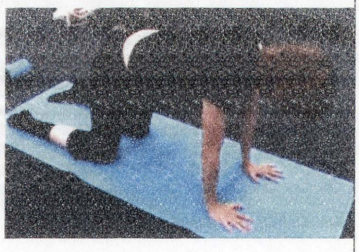
> *I found that I was in my body acting rather than imagining my body acting* (Participant 3, Pilates)

Descriptions of movement in terms of space, time and dynamics are descriptions similar to those used in Labanotation (e.g. Hutchinson 1977), which I cover more extensively in Chapters 2 and 4.

5.2.2 "How it Feels to Move when I'm Doing it Right"

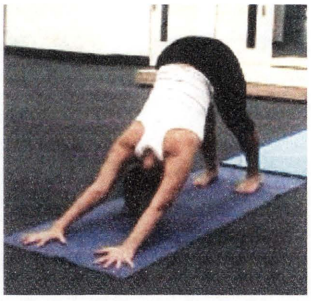
Awareness of *neutral spine* alignment is emphasised throughout all Pilates exercises. This is one of the fundamental poses, and one which all Pilates practitioners in the study performed. See Table 5.3 for the researcher's observations and Participant 4's description of knowing how it feels to do neutral spine.

Table 5.3: Neutral spine in Pilates, Participant 4

Objective Description What the body is doing	Objective Recording What it looks like	Subjective Description How it feels when I'm Doing it Right
Neutral spine is the natural position of the spine when all body parts are in good alignment. When the spine is in neutral, the natural curves of the cervical and lumbar spine are maintained. While on all fours, neutral spine is achieved by moving the pelvis up and down (and some-times sideways), and finding a point where the practitioner feels balanced and the instructor confirm this.		*I just love the feeling of straightness that you get, and the feeling that your body is... moving through a...it's that whole...you know you are sitting in a chair and all of a sudden you notice that you are sitting very straight and you can feel how your body is in alignment and I love that feeling of...sort of... I don't know what to call it!*
Researcher's articulation of shape and spatial path	Practitioner's bodily articulation	Practitioner's verbal articulation

In yoga, *downward-facing dog* (Adho Mukha Svanasana in Sanskrit) is one of the basic poses, and one all the participating yoga practitioners performed. It is a versatile pose in that it incorporates elements of standing poses, arm balancing, forward bends and backbends. In one of the classes I attended for this study, the instructor used the expression *the garlic of all poses* when describing it. See Table 5.4 below for Participant 2's description of knowing how to do downward-facing dog.

Table 5.4: Downward-Facing Dog in yoga, Participant 2

Objective Description What the body is doing	Objective Recording What it looks like	Subjective Description How it feels to do when I'm Doing it Right
The palms are positioned shoulder width apart with the fingers spread and the middle finger facing forward. The shoulder blades are worked flat on the back, the collarbones are broadened. While pressing the palms into the mat, the arms, side chest and waist are extending to lift the sitting bones to the ceiling. The heels are extended towards the floor while lifting evenly through the ankle, knees, thighs to work the legs straight. The head is encouraged to hang.		*In this pose the knowing that I'm doing it right means a feeling of energy flow, there is an ease in pose, you are not sweating, the body is not hard, and there is no pain and the effort is evenly distributed.*
Researcher's articulation of shape and spatial path	Practitioner's bodily articulation	Practitioner's verbal articulation

The *Armada*, similarly to many moves in Capoeira, radiates out from the base movement *Ginga*. Knowing how to perform the Armada was described in terms of stability in the performance and being completely set up to keep moving. See Table 5.5 for Participant 1's description of doing the armada, one of the basic standing spinning kicks in Capoeria.

Table 5.5: Armada, standing spinning outside crescent kick in Capoeria, Participant 1

Objective Description What the body is doing	Objective Recording What it looks like	Subjective Description How it feels to do when I'm Doing it Right
A straight back leg is brought forward, up and around in a sweep-like motion. The upper body moves back and the arms swing around to counter the weight of the leg moving forward, up and around with speed. The moving leg is placed back down behind while the arms return to the Ginga position.		*The feeling of achievement if you've done it well is that you are completely set up to keep moving*
Researcher's articulation of shape and spatial path	Practitioner's bodily articulation	Practitioner's verbal articulation

Of the three movements described here, *neutral spine* is an exercise in itself; however achieving neutral spine is sought as an ideal position of the spine in many other exercises in Pilates, which means there is a continual challenge to keep the body in that position and to keep the *right* feeling. In *downward-facing dog*, the correct execution and feeling of effortless mastery is one of external stillness. The muscles are working, but once a practitioner is into the basic alignment of the pose, there are

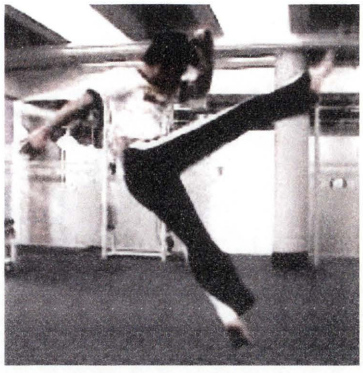
very minor changes in spatial orientation. Most of the work is within the position the body is in and internal to the body, for example, rotating the inner upper arm up, lifting the knees and so on. In the *Armada*, the challenge is to achieve and maintain the kinaesthetic and proprioceptive experiences throughout the kick. So, when performed correctly, all of these three movements might look effortless. However, there is tremendous effort involved. When performed correctly, the effort is distributed and timed just right.

5.2.3 "How it Feels to Move when I'm not Doing it Right"

The previous section presented the participants' articulations of the kinaesthetic and proprioceptive experiences of *how it feels when I'm doing it right*. The participants also recounted experiences and times when they did not find or achieve perceptions of fluid performance. Over time, they have, as learners, developed a capacity to perform or act in particular circumstances in their practice, though there are still times when they do not perform at that capacity. The process of coming to know also includes experiences of not being able to move the way one wants, and strategies for searching to find or achieve the fluent kinaesthetic and proprioceptive experience.

Two different situations are involved here. One is before a practitioner learns to recognise the particular set of perceptions that go along with kinaesthetic and proprioceptive fluency and effortless mastery. The other is once a practitioner has had the experience (s/he knows and can recognise the perceptions) of what it is like to do it right, but for some reason fails to either recognise or achieve this. Once a movement practitioner has *got it*, that is, caught on to how it feels to do it right, the challenge becomes to *find, access* or *achieve* this feeling (these were all terms used by the practitioners). Participant 12, a capoeirista, spoke about *nailing* the *Armada Martelo* a double jumping spinning kick with the torso parallel to the floor. (*Armada Martelo* is also called Armada com Martelo or Parafuso). See Table 5.6 below.

Table 5.6: Armada Martelo, double jumping spinning kick in Capoeria, Participant 12

Objective Description What the body is doing	Objective Recording What it looks like	Subjective Description How it Feels to do when I'm am Doing it Right
The kick is initiated like the Armada. As the leg begins to kick, push off of the standing leg to utilise the momentum of the Armada to spin the body up into the air. The Armada leg is followed by the second leg in Martelo. Bend the leading leg and pivot hips back to bring the leading foot back into the Ginga position. The arms work in opposition throughout the kick.		*A friend of mine said "it is like a soccer kick." I tried it and that was the one and only time it felt good. yupp, that is what it is supposed to feel like. So I feel like have experienced once the feeling what it is, what it is to do it properly*
Researcher's articulation of shape and spatial path	Practitioner's bodily articulation	Practitioner's verbal articulation

Although this capoeirista found this particular move very challenging, though fun to do, *not a lot of people do it*, he said. He was continuously searching for the *right feeling* or perception from that one time when it felt right. Participant 6 (Capoeira) spoke about trying to find the feeling which for him was located

> *...somewhere between the head and the body* (Participant 6, Capoeria)

5.2.4 Strategies used to Find the *Right Feeling*

Instructors interviewed commented that they try to employ strategies that will help people get access to or locate the right feeling. Particularly Pilates and yoga instructors talked about when they can see that people are struggling to *get it* they might try a number of strategies, including demonstrating right and wrong ways of doing a pose/exercise themselves, using another practitioner as an example, talking directly to the person who is having difficulty (rather than talking to the group in general), or touching and/or moving a practitioner's body part.

> *Sometimes you ask a person to move their hip and nothing happens. Sometimes you have to actually touch the body part.* (Participant 7, Iyengar Yoga)

> *I try to give instructions that will give them an access into the pose, a way of understanding the pose, a way of doing the pose.* (Participant 2, Iyengar yoga)

By touching a body part, the instructor helps a practitioner direct their focus and attention to the part of the body or muscle which should be activated and engaged. By moving a body part into the correct alignment, the instructor helps a practitioner get a

sense of the way a move or pose is supposed to feel. Touch, as well as repetition of moves, watching other practitioners, props and pain were emphasised by the practitioners, as well as instructors, as ways to access and recreate the right perceptions.

> *I need to find a way that physically will show them immediately... I find that using little toys when there are instabilities demonstrate...make them a little more attentive.* (Participant 13, Pilates)

By physically challenging the practitioner (in the sense of making them more attentive, not challenging them to a fight) this instructor uses toys or objects to show instability where stability is required to enable the practitioners to get a feel for the right perception and how to do a movement right. For example, for an exercise that require stability in the sacrum, a small ball is placed on the sacrum. If there is instability in the sacrum the ball will roll off, indicating to the practitioner that they were not keeping the sacrum still even though they thought they were.

Using imagery was mentioned as another powerful tool by both practitioners and instructors, as seen in this comment from Participant 13, a Pilates instructor:

> *...what I do realise, if I can give people an image with the movement, their recruitment patterns will be much much better...if you can give them images to work with... ...people want to know that I'm gonna focus in to this particular bit of my body or that bit of my body, this isn't necessarily gonna bring out the best in the total body. ... they do much better with an image and I try to use images like "space between the shoulder and ear" rather than "pull the shoulder down" because a lot of people overly depress the scapula.... [and] if you tell people to "float" the arm up they'll tend to retain length through the body OK. Whereas if you tell people to focus on a muscle and lift the arm even of you tell them to pull shoulder down and lift the arm up you get all sorts of body distortions.* (Participant 13, Pilates)

Interpreting this using Laban's work (e.g. Laban 1971) we could say that the imagery *float the arm* has more information in terms of execution of movement than *lift the arm and pull the shoulder down*, which indicates spatial direction, but not about the execution of the movement. The image, *float the arm,* also gives an indication of which muscle to engage and the spatial path of the movement, that is, the imagery includes descriptions of the *effort* involved.

Among the questions I asked in the interview, was one where I asked the practitioners to tell me about a movement they have had trouble learning. Two practitioners specifically mentioned that imagery had enabled them to improve. A capoeirista (Participant 6) working on a forward cartwheel (Au de Frente) was constantly finding,

through experience and feedback from instructors and other capoeristas, that he was coming through the cartwheel lopsided. The hips are supposed to come straight over the head, but instead his right side would swing over first. When he was told to think of it as *rolling down a hill*, he said, he had a glimpse of how it was supposed to be done and finally started to improve. Participant 4, also described this glimpse of the right feeling as helping her improve,

> *When I was told to "reach and lengthen" rather than just raise arm, I was like...* [here the practitioner stops talking, raises her eyebrows and displays what I would describe as a "light bulb" moment] (Participant 4, Pilates)

Sometimes, finding the right feel is really hard, as in this quote from Participant 1, describing a continuing struggle with the Armada, the Capoeira spinning kick, as *floating in and out of knowing*.

> *...it is like that... like the difference between knowing it and knowing it totally. It becomes a mental thing, I can't access it again...until it becomes completely embedded in my... where I don't have to access it mentally. Soon as I have to start thinking about, right, where should my foot...and then I think not far enough around – it's gone, it is totally totally gone. Unlike some things where if I don't think about it, I do it, it comes back to me. Absolutely this one I sometimes have to go ask someone, I've almost developed bad habits when I'm trying to figure out what the problem is. With some of the double kicks I know, I know why. While with this one I still don't know why ...why am I coming off balance? So I feel like I float in and out of knowing how to do it.* (Participant 1, Capoeira)

The practitioner described the problem as one of *balance*; the core of the problem is still the same, finding back to the right feel. In the struggling to identify the problem in her performance, the practitioner has resorted to asking others what the problem might be. If kinaesthetically and proprioceptively accessing the perception fails, practitioners tried to identify and reiterate the perception through other senses, for example sight,

> *Sometimes I can't just do it or think it, I have to actually look at the body parts to remember how to do it.* (Participant 4)

Here the practitioner is trying to access the knowing kinaesthetically and proprioceptively, but has to reinforce with visual perception.

Then there are the times when one does not know what a movement is supposed to feel like. While participating in a yoga class, the instructor asked us (including the researcher) to perform a backbend (*Urdhva Dhanurasana*, upward bow or wheel pose). I remember thinking

> *I have no idea how to do this. I can't even imagine how to get from lying on my back into that pose* (my experience, yoga)

I could tell from looking at the others what the pose was supposed to look like, so I figured I just had to do something and see what would happen. I arched my back, planted my hands and feet into the mat and pushed off. It is very unlikely that it was an exhibition of *effortless mastery*, but it got me into the pose and I got a first understanding of what it was like to do the Urdhva Dhanurasana.

The use of imagery was described as important, but not the only way to come to learn or improve upon the performance of a movement. Some of the other ways the participants described were:

- Particular ways of moving, e.g. paying attention to the way one moves, types of movement, how to use movement;
- Critical incidents with experiential implications, e.g. instruction, injury, pain or pain avoidance; and
- Ways of moving in relation to touch, space or props.

I describe this last one, ways of moving and the experiential descriptions in relation to touch, space and props, in the next section. This is important both for the development of the feel dimension and for developing understandings for interaction design.

5.2.5 Felt Qualities in Relation to Touch, Space and Props

Although rarely described verbally by the practitioners as part of their movement experiences, I started noticing a way of moving performed before the movements the practitioners would describe to me. These preliminary movements seemed to be done for preparation, assessments, *to get a feel* for a body part, a move or a position. This could be for example:

- A shrug of a shoulder before starting a new roll down in Pilates;
- The shake of a leg before another kick in Capoeira;
- The tentative pulling of the handle attached to the Cadillac to figure out how much power to use for a chest exercise in Pilates while still maintaining the correct positioning or alignment in the rest of the body; and

- Repositioning of a wooden block in yoga to *get the right feel* in a particular pose.

These movements and ways of moving were not done incorrectly or performed contrary to instructions, but performed with a level of exploration, curiosity and play. For example, when I described this observation to Participant 1, she said

> *Sometimes I do part of an Armada to feel how far I need to lean back before my hamstrings engage.* (Participant 1, Capoeira)

In this case, preparatory movements were carried out to test the *range* of the movement she was about to carry out.

My interpretation of these experiences at the kinaesthetic and proprioceptive level is that this is a way for the practitioner to *connect* with a body part and to establish a frame of reference for a *dialogue* with a muscle, a body part or a prop. Similar movements can be observed in the twirling of the tennis racket in a player's hand before receiving or hitting a serve, the bouncing of the ball by a basketball player to get the precise feel for the ball before attempting a penalty, or the weighting of a tool or material in the hand of a person skilled in their craft.

> *In yoga, props can get you into a pose if you are injured or stiff, but props can also become a "cushion" ... you use props* [for support] *rather than pushing through posture.* (Participant 2, Iyengar yoga)

Both the presence and importance of props are evident in the movement experiences described above. From the practitioners' articulations I recognised that the props were experienced as extensions, such as the blind man's stick, as described by Merleau-Ponty (1962). However, this notion did not entirely seem to cover the experience described by the participants. This was particularly relevant for the way things were used among the participants who are yoga and Pilates practitioners. Rather than being described as an extension of the body, the things used in yoga and Pilates were described as

> *accessories, aids or mediators with purposes such as providing feedback to create awareness, extend reach, lengthen, take weight off, protect certain muscles, isolate specific muscles, or enable connections between parts of the body.*

In the same way a prop can be important in order to find the fluent experience in yoga and Pilates, (as the practitioner would not have been able to achieve it otherwise), the

Roda with the music, instruments and the other capoeiristas become props necessary for a fluent experience in Capoeira. However, the relationship between the mover and that which influences the mover and their movements is of a different character in Capoeira. The importance of the music in Capoeria was articulated by Participant 6, who said

> *...the exercises are dull in classes without live music, it's mechanical... In the Roda it is clean, crisp, beautiful, and the music helps me link from one move to the next* (Participant 6)

In Capoeria, it is about the space and event created for the game in the Roda, Clifton (1983, p. 70) quoted in Downey (2002) said

> *Music, like space, can be experienced not merely as an object outside the self, "but as field of action for a subject"* (in Downey 2002, p. 498)

The Roda, as lived space, is important for the proper execution and the right *feel* of a move in Capoeira. Several capoeiristas spoke about the difference in doing moves in the Roda versus just practising moves. Until they have mastered a move in the Roda, they do not consider themselves to *know how to do* the move.

> *I don't know how until I have nailed it in the Roda, it is easier to do it [a move] in regular training than in the Roda.* (Participant 12, Capoeira)

> *In the Roda I'm much less likely to do it properly. I can do lots in training that don't do in Roda; I can't put it into the game properly.* (Participant 1, Capoeira)

The point I want to emphasise here is that our actions, in this case movement, unfold in space that is the lived space of the Roda (Capoeira), or the lived space created in the relationship between the body and Cadillac (Pilates), the body and wooden block (yoga) or the body and the Roda or the music (Capoeria). And, that when moving in space in relationship to a thing, the mover's body *dialogues* with the things and establishes relationships to the prop. Our perception of the relationship between the body and space, and things in that space, depends on mechanisms that combine sensory cues (if we have this sense intact) and signals connected to our actions.

In Pilates and yoga, props make a person aware of the limits of their body and they enable a person to achieve some internal effect. While in Capoeira, (in tennis or when using stilts, for that matter) the effect one wants to achieve is external to the body, though there is also a change internally as a result of this. The process of trying to

understand this experiential difference together with Merleau-Ponty's concept of body schema are important aspects for the development of the feel dimension in Chapter 7.

5.3 Discussion and Reflection

I have, in this chapter, looked at how thirteen participants in three movement disciplines articulated their *experience of moving*. From the findings reported above, I describe how the participants' *relations to their (movement) world* are transformed as they acquire skills, and I develop a *continuum of knowing and understanding*, as well as make some suggestions about the implications of my findings for interaction design.

5.3.1 Lived Experience, Lived Relationships in the Movement Dialogue

> *The analysis of motor habit as an extension of existence leads on, then, to an analysis of perceptual habit as the coming into possession of a world.* (Merleau-Ponty 1962, p. 176)

Merleau-Ponty (1962) also said that, skills are acquired by dealing with things and situations, and in turn they determine how things and situations show up for us as requiring our responses. The qualities of kinaesthetic and proprioceptive movement experiences illustrate the characteristics and conditions of the experience of the lived body, the various relationships involved, and they try to articulate how our relations to our world are transformed as we acquire skill. All these elements together make up the *lived experience*. Different aspects of the lived experience can be differentiated, but not separated in human experience.

In the experience of coming to know and perform movements, there is the sense of *lived time*,

> *...so I feel I experienced once the feeling what it is, what it is to do it properly* (Participant 12).

The saying *learning happens over time* holds true. However, *lived time* is about the subjective experience of time rather than time as shown on a watch, when *the movements are too fast for the mind to keep up* (Participant 1, 7 and 9), or the sense of time in the moments that proved to be particularly powerful in terms of learning.

Lived space is felt space and our spatial way of being in the world. The space we are in with instructors, other practitioners and props affects the way we feel and the way we move. In the study, the participants spoke about and demonstrated, and I observed and experienced, the movement practices as constituting a set of particular *places* and

actions. The places being: at the yoga school on the mat, using the wall or the rope, in the Pilates studio on the Reformer or the Cadillac, and at the Capoeira academy in the Roda playing, forming the Roda or practicing outside the Roda. As well there are *particular actions* - movements and routines the practitioner is intending to perform, and particulars of the movements. The particular experience of kinaesthetic and proprioceptive fluency takes place at a particular time, in a particular setting, in a social and collaborative process between practitioner, instructors, other practitioners and the props used. All of these influence the way one moves, they become frames of reference for movements that a body uses to organise perception and action.

Implications of Findings for Interaction Design

In terms of *space*, the Roda or the props in yoga and Pilates will determine the relationship between the practitioner, his/her movements and displacement in a space. How do the movements performed in time and space set up the practitioner for what is happening next? For interaction design this suggests that not only is it important to consider how or what movements the technology makes the practitioner perform in order to enable interaction, but also about how it sets the practitioner up (or not) for what is to happen next.

This is because one movement must be seen in relation to both the preceding and the next. The next movement is being planned while the current one is being carried out. In a fluent movement experience, the mover is in the *now*, because the focus is on the movement being carried out, but what is happening now is also directed towards what is coming next. In terms of *time*, therefore continuity is more important than discrete moments in time.

5.3.2 Continuum of Knowing and Understanding

The participants' reporting of their kinaesthetic and proprioceptive movement experience told me that over time they have come to a certain level of knowing in their practice, that is they have developed a capacity to act and perform in particular circumstances in their practice, though there are still times when they do not perform at that capacity. They have developed both the ability to do movements as well as the ability to recognise the performance of movement. This relationship between *experience* on the one hand and *understanding and knowing* on the other is probably best understood in terms of the meaning making that takes place in our ongoing

movement dialogue within the particular circumstances in which we act (described in the previous section), in this case with neutral spine, downward facing dog and Armada. By abstracting the findings about movement experiences, I identified a distinction between bodily knowing and bodily understanding, a distinguishing characteristic of experiential bodily knowing, which I believe could be useful characteristic for interaction design.

If represented on a continuum, the participants' experiences show a continuum of knowing from *not knowing how to move* to *knowing how to move completely*. The distinction between bodily understanding and bodily knowing, is that we, at different times, at the same level of knowing, do not always perform consistently and what the experience of this is. This is illustrated in the quote by Participant 1, Capoeira, describing a continued struggle with the Armada, the Capoeira spinning kick, as *floating in and out of knowing* (section 5.2.4). The continuum of knowing and understanding is detailed in Table 5.7 below with representative quotes. The connections between the stages in the continuum are outlined below the table, though they will evolve over time. These stages are not exhaustive or exclusive, they both overlap and interact.

Table 5.7: Continuum of bodily knowing and understanding

Not knowing how to move...	Knowing how, but not be able to move...	Not knowing that I know, but being able to move	Knowing how to move	Knowing how to move completely
It is gone (Participant 1)	*Sometimes can't just do it or think it, I have to actually look at the body parts to remember how to do it.* (Participant 4)	*I remember this one time, I just couldn't think or imagine how to do that pose (an inversion), so figured I just had to do something and see what would happen. It got me into the pose!* (My experience)	*Yes that is what it is supposed to feel like. So I feel like have experienced once the feeling what it is to know, what it is to do it properly.* (Participant 12)	*Skill is just there to use* (Participant 3) *Feels like a spring* (Participant 9) *Like floating on air* (Participant 6) *Completely set up to keep moving* (Participant 1)

At different points[3] along the continuum a practitioner is able to perform with increasing degrees of awareness, recognition, and understanding of well-executed

[3]This might seem reminiscent of stages of *stages of skill acquisition*, which delineates the learning of skill from novice – expert (e.g. Dreyfus and Dreyfus, 1986). However, the distinction I am aiming to highlight here is in terms of experiences of knowing, and about how we, at different times, at the same level of skill, do not always perform consistently and what the experience of this is.

movement in oneself and others. Another Capoeria practitioner expressed striving for knowing how to move completely this way,

> *"I have accumulated all this knowledge, now how do I use it to master expression of moves?* (Participant 9, Capoeria)

The *expression of* moves means the experience of performing consistently, and being able to perform with poise and flare. The experiences presented in the continuum suggest that for experiential bodily knowing, not only might it make sense to experientially differentiate between degrees of knowing, but also between knowing and understanding. That is, how one can be able to bodily understand, but not yet perform, yet also perform without explicit bodily understanding. This is illustrated in the middle quote in Table 5.7. It is this insight which I argue (below), might be useful for interaction design.

Implications of Findings for Interaction Design

My findings suggest that the movement experience of the knowing required and involved in doing neutral spine, downward facing dog, Armada and all the other movements in the three disciplines is a knowing *how* and that this knowing is *felt* and *achieved* through moving. The performance of the bodily practice is the way to display this knowing experientially. This mutual constitution of knowing and doing rather than knowledge as a given, is resonant with Polanyi's tacit knowing (1983). Experiential bodily knowing as talked about in this chapter is a form of tacit knowing.

The distinction arising from the continuum about the relationship between experience on the one hand and understanding and knowing on the other, (that is being able to do, without explicit bodily understanding), could be useful for interaction design, particularly in coming to an understanding of movement as a material for design. The designer/mover can interrogate and reflect on movement by moving, doing and performing with movement. Though as pointed out by our study participants, the moving/doing/performing needs to be guided by something that focuses or triggers the designer's/mover's attention and awareness. If one agrees that experiential bodily knowing is felt and is a knowing how, this means that meaning is produced in and through movement. For interaction design, this is a recognition that the only way we will have access to or know certain things is through moving, in which case

interaction designers should move as part of the process of designing – it is about production of meaning in and through movement.

Awareness and reflection in this movement dialogue is key to being able to benefit from understandings that can be generated this way. The participants spoke about awareness and making conscious the movement experience as important for increased knowing. Awareness could emerge through affirmative movements, e.g. moving in relation to both external (e.g. vision, hearing, touch, props) and internal (kinaesthetic and proprioceptive senses) points of reference, as well as injury, (as mention in section 5.2.4).

5.4 Conclusion

From the empirical findings in this study, I generated different articulations of experiences of moving. The kinaesthetic and proprioceptive experience of a fluid performance is one of a perception of the body's interaction in the world, in terms of the kinaesthetic and proprioceptive senses, sight and touch. There is a particular set of perceptions that go along with a fluent experience (performance), and the mover must learn to recognize and achieve these. This is learning what it feels like to do something right. The mover must learn how to achieve this particular feeling, with her or his particular body, in a particular setting, at a particular time, sometimes without knowing in advance what this feeling is. From the point of view of kinaesthetic and proprioceptive experiences, a movement practitioner has to catch and understand *how it feels when I'm doing it right.*

The different articulations of the movement experiences; articulation of shape and spatial path, bodily articulation and verbal articulation helped me come to these understandings. As such working with these articulations (i.e. representations) became a tool that helped me reason about movement in the same way Labanotation and the other frameworks were used in Study I. It also made me realise the incompleteness of relying only on verbal articulations of movement experiences.

Furthermore, from the analysis of the data, I also recognised that the props used in the three movement disciplines studied were experienced as extensions, such as the blind man's stick, as described by Merleau-Ponty (1962). However, props were also experienced and described as aids or mediators and so on. Together with Merleau-

Ponty's body schema, the process of trying to understand this experiential difference becomes important when developing the *feel dimension* in Chapter 7.

In the next chapter, I describe the third and final study. This study was carried out with professional movers as participants. The study had the aim of furthering my understanding of movement as a form of knowing, by exploring the far end of the continuum where movement is performed as *knowing how completely*. In doing so I sought to understand more about movement as material for interaction design.

Chapter 6
Study III: A Study of Professional Movers

This chapter reports on my third study, in which I studied professional movement practitioners with the aim of furthering my understanding of movement as material for interaction design. The study informed my understanding of both properties of movement and movement practice.

> *When artists, designers, architects and engineers build an understanding of the properties of a material, they often study it by creating a structured collection of basic examples that explore different aspects and properties of the material. A basic understanding of the properties of, e.g., wood, paint, concrete, as materials for design, can perhaps only be achieved by working with them in practice. More systematic studies of the material are then used to map out the design space of possible expressions.* (Hallnäs et al. 2001, p. 195)

My second study described the experience of a fluid performance as a perception of the body's interaction in the world, in terms of the kinaesthetic and proprioceptive senses, sight and touch. A mover must, with her or his body, learn to recognise and achieve the particular patterns of sense perception that go along with fluent performance of effortless mastery. Further, my findings suggest that the knowing required and involved in doing the particular movements such as those explored in Chapter 5 is a knowing *how*, and that this knowing is *felt* and achieved through moving. The doing of the practice is the way to learn and to articulate this knowing. I also developed a continuum of knowing as a description of the nature of bodily knowing. In the continuum, a distinction is made between bodily understanding and bodily knowing, when knowing is constituted by doing.

This third study became a further exploration of the nature of bodily knowing and understanding, which I approach by examining the end of the continuum where knowing is not only constituted by doing movement, but by *performing movement* as it is in professional movement practice. The study continues the examination of craft and movement as a form of knowing, which I first described in Chapter 2 and also addressed in the second study in Chapter 5. In this third study, movement is explored as a material for design, in terms of the properties of movement. In addition, the study picks up on the four sensitising principles that emerged from studying the literature, available applications and technology early on in this research project (see Chapter 2). I identified *tangibility, proximity, dynamics* and *body schema* as potentially relevant to movement-enabled interactions. Working with these concepts in practice, helped me explore and understand properties of movement as a material, as well as the nature of professional movement practice.

The findings from this third study are reported here, and further discussed and conceptualised in the subsequent chapter (Chapter 7) where I develop the theory of

the feel dimension, and the concepts of movement understanding as a design (sens)-ability in interaction and design questions following from my exploration of the feel dimension. The work in this third study helped further refine, reinforce and extend these three concepts.

6.1 Study Setting and Participants

Madina, a suburb northeast of Accra, Ghana was the setting for the study. Here I worked with the director and dancers at the Noyam African Dance Institute[1]. Noyam is translated as *moving on* or *development* in Ga-Dangbe. Ga or Ga-Dangbe is the language of the Ga people native to the Greater Accra region. Noyam's repertoire consists of contemporary African dance using many elements from traditional African dance, but also elements from ballet and other genres. Dance is traditionally not practised as a profession in Ghana, although this is changing. The Noyam Institute is, so far, one of very few of its kind providing pre-university level all-round dance training, covering topics such as life as a dancer, economics, massage, nutrition and so on.

Noyam is headed by the choreographer and former dancer F. (Francis) Nii-Yartey, who, until the Summer of 2006, was also the head of the Ghana National Dance Company. In addition, thirteen different dancers, six female and seven male dancers, participated in this study. On any one day there would be between six and nine dancers present. There were four senior dancers in their late-20s to early-40s, the rest of the dancers were junior dancers in their early 20s (the terms *junior dancer* and *senior dancer* are the dancers' own). These thirteen dancers would perform as part of Noyam; some also performed on their own or were involved in other groups. See Table 6.1 for an overview of the dancers' age, gender and seniority. The dancers are numbered in the order in which they were introduced to me.

[1] http://noyam.org

Table 6.1: Study III participants

No	Age	Gender	Seniority
Dancer 1	28	F	Senior
Dancer 2	36	F	Senior
Dancer 3	20	F	Junior
Dancer 4	22	M	Junior
Dancer 5	22	M	Junior
Dancer 6	32	M	Senior
Dancer 7	15	F	Junior
Dancer 8	21	F	Junior
Dancer 9	42	M	Senior
Dancer 10	33	M	Senior
Dancer 11	20	M	Junior
Dancer 12	21	M	Junior
Dancer 13	24	F	Junior

Of the thirteen study participants, two male junior dancers joined the Institute during my last month there and a female exchange student from the Netherlands was a temporary member of the dance institute for the duration of my stay. Two of the dancers had been members on and off since the Institute's inception in 1998, the rest had joined since. One of these two initial members is now teaching dance and choreography at a university level institution in Europe. I was told Noyam regularly hosts visitors, dancers, choreographers and academics; several other visitors came and went during the time I was there.

The dancers had varied backgrounds from sports such as soccer, athletics, and different dance forms, such as ballet and break-dance. Most had danced most of their lives; this corresponds with Nii-Yartey's remark that *dance is not traditionally practiced as a profession in Ghana, but rather an integral part of the cultural life of people.* [2]

6.2 The Study

Over the three month period I spent at Noyam, the end of February until the end of May 2006, I worked with the dancers on average two days a week, usually Mondays and Wednesdays. I also attended the majority of their performances in this period and some onsite rehearsals. During this time I observed and participated in the daily regimen of training and preparing for performance, I also ate breakfast with the

[2] This is certainly the impression one gets from observing and experiencing everyday life in different settings in Ghana. This does not mean that every single person in Ghana enjoys dancing and does it whenever the opportunity arises; however dancing is a common activity in many social settings, e.g. funerals, church, celebrations and so on. People of all ages take part. Knowing how to dance is not really an issue, it is just something one does.

dancers, warmed up with them, shared mid-morning snacks and intimacies, filmed performances; we caught the tro-tro (a form of public transportation ubiquitous in Ghana and most of West-Africa) to the city and went to the market together. On a day-to-day basis a session would usually start around 8.00-8.30am. The sessions took place outdoors on a smooth black surface which would get very hot as the day progressed, so rehearsals would usually finish up around midday or so, depending on the amount of work needed to prepare for upcoming performances.

My aim for the study with Noyam African Dance Institute was to learn from professional movers about properties of movement by experiencing - seeing, feeling, trying and observing - their practice. As a study, the time I spent with Noyam proceeded through a three stage process. The first of the three stages aimed to lay the groundwork for reflection both for the dancers and for me. Then came a period where both the dancers' and my developing reflections were interrogated, new ones triggered, questioned and captured. The finally stage was one of gathering the thoughts and ideas that had been maturing.

In the study, I asked the dancers to perform exercises for exploring movement and to orient them to issues I wanted to explore. I combined the exercises with individual interviews, group discussions, observation and participant observation; similar to the methods used in the second study. The methods were carried over from the previous study for two reasons. First because they seemed to have worked well in helping the participants in Study II access and make conscious their movement experiences. Second, it kept my methods consistent and added rigour to this aspect of the research.

The exercises were developed around and inspired by the sensitising principles: tangibility, proximity dynamics, and ideas about Merleau-Ponty's body schema, as well as understandings I had acquired from working with Labanotation and my growing understanding of kinaesthetic and proprioceptive experiences. The exercises and discussion topics used in interaction with the dancers were a way for me to articulate and share the insights I had reached at that point, and a way to engage the dancers in reflection about their materials - their bodies and the movements they could or might perform, properties of their materials and their practice. The specific topics addressed in this study and the purpose for which they were address are presented in Table 6.2 below. A number of the topics mentioned below are being revisited from

the previous two studies. This is deliberate as one of the core aims of this third study was to work with and learn from movement professionals, people whose craft and material for design is movement.

Table 6.2: Focus and purpose of topics addressed in Study III

	Topic	Purpose
1	Reflection, both in the abstract and tied to specific experience: what it means to be bodily literate and bodily aware; different aspects of bodily sensations; how to make movement experiences conscious; and ways of articulating movement experience.	To further my understanding about the nature of bodily knowing and understanding. These questions directly pick up topics from Study II.
2	Doing, performing, teaching movement; different ways of doing movement and working with movement in different capacities:.	To further my understanding of movement practice about what it means to really know and understand movement.
3	Creation of choreographies around and teaching from the sensitising principles tangibility, proximity, dynamics, body schema	To learn from movement professionals about how they interpret these principles and work with them, both to explore whether my research to that point had addressed the depth of these terms and for potential inspiration for activities for interaction design.
4	Experience of and choreographing for relating movements to a specific point on the body vs. the whole body.	To examine developing understandings: from Labanotation where one can work with the whole body as well as a body part, and from interactions with different technologies, e.g. a piece of technology can be affixed to a particular part on the body, it can be held more or less still in the hand, or the technology must be moved around for interaction to take place.
5	Use of space, time and dynamic when dancing and choreographing.	To examine developing understandings from Labanotation.
6	How to create and convey a sense of connection between dancers.	To investigate a challenge identified for technology interactions lacking a traditional GUI: how to ensure the right technology or sensor is addressed. This topics aimed to find out how the dancer would work with this.
7	Properties of movement, in particular, how to work with movement to indicate where a movement starts and stops.	To investigate another common challenge for technology.
8	Visual versus kinaesthetic and proprioceptive experiences when moving	To gain the view of movement professionals' on this topic.
9	How props are used and how props influence dancing and choreographing.	To further understand the relationships involved in these movement experiences

6.2.1 The Beginning

In my first encounter with Noyam, I met Nii-Yartey in his office at the National Dance Company in downtown Accra. We discussed my project, our collaboration, different types of dance, dance as a form of movement practice, dance and technology and so on. The following week I met with the dancers in Madina. I introduced myself

and my research. The dancers introduced themselves and performed an excerpt from a piece they had recently performed in the Netherlands and Belgium, called *Dance of the Forest*. See images in Figure 6.1 below.

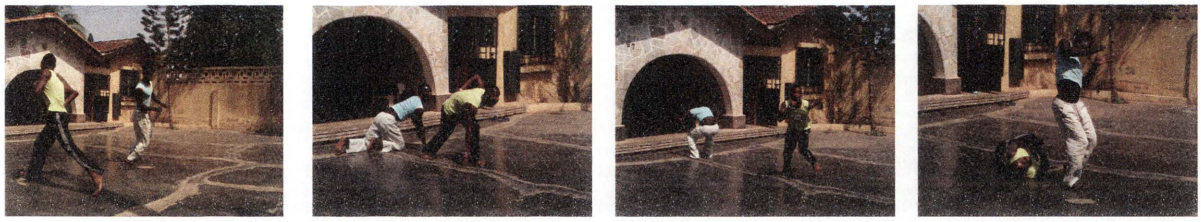


Figure 6.1: Stills from *Dance of the Forest*

After these first encounters, I spent a few sessions mainly being present, talking and observing. The rehearsal sessions were generally led by one of the senior dancers, but they all took turns leading the warm-up. After a while I would usually participate in the warm up, which consisted of a variety of dance moves: traditional African to salsa to hip hop. Then the dancers would do whatever they needed to do on the day, while I would participate or observe, sometimes asking questions, and usually take pictures. At the end of the session I was given time to run my exercises, conduct group discussions and interviews. During the course of my stay, both old and new performances were worked on and developed. As such my study did not follow the development or rehearsal of one particular performance or piece.

During the first few weeks we discussed reflection, both in the abstract and tied to specific experience: what it means to be *bodily literate* and *bodily aware*; different aspects of bodily sensation; how to make movement experiences conscious; and ways of articulating movement experience. During this time my activities were geared towards laying the ground for reflection. One of the things I wanted to improve from the previous study was to engage with the practitioners' reflection as it unfolded over time, rather than in intermittent snapshots.

6.2.2 The Middle

The middle period was marked by my more active participation and intervention. I participated more (and more frequently) in their rehearsals and I directed two exercises. The first of these exercises was an exploration of visual versus kinaesthetic and proprioceptive perceptions when moving. We had previously discussed the topic of what something looks like versus how it feels to do. In the exercise, the dancers

were asked to perform a piece familiar to them, dance blindfolded and then draw the visual image and the kinaesthetic and proprioceptive experiences of their performance. This was an interesting and a useful exercise for reasons of outcome as well as facilitation. The images in Table 6.3 show a collection of the drawings on the left and Dancer 13's drawings of the visual image (middle) and experience of performing (right).

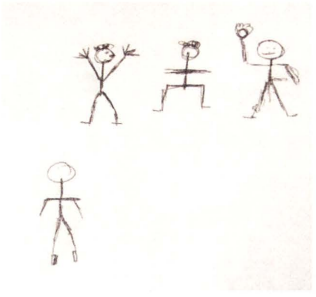
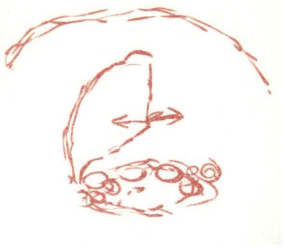
Table 6.3: Comparing visual image and kinaesthetic and proprioceptive experiences

Collection of drawings	Dancer 13 visual image	Dancer 13 Experience of performing
		

The dancers were surprised by the extent to which they found themselves to be guided by vision when moving. This was one important aspect of this exercise, to heighten the sense of movement, which for most people is subordinate to visual perception. This also seemed to be the case for the dancers. We repeated the exercise a few times for the purposes of exploring the core idea of the exercise, to get a better sense of the nature of the experience and to improve our explanations. The dancers repeated and experimented both with their performance pieces and drawings until they were satisfied that their drawings, to the extent possible, were a good illustration of their experiences.

The dancers drew one or several pictures illustrating the whole danced sequence, images of their pieces frame by frame, and the body and its motion as stick figures, spirals, directions-in-space and being in more than one place at once. See Dancer 8 and Dancer 5's explanations and drawings in the two Tables 6.4 and 6.5 below. Dancer 8 performed her part from a performance piece they were working on.

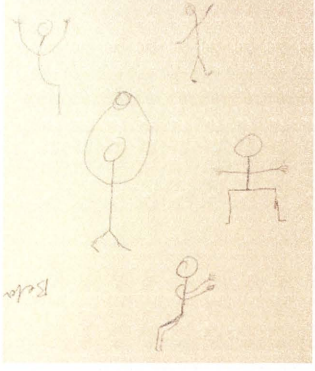
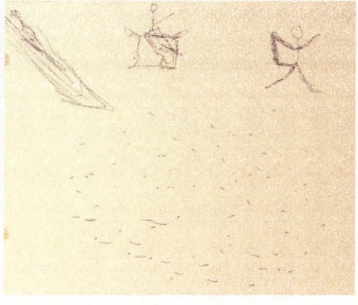
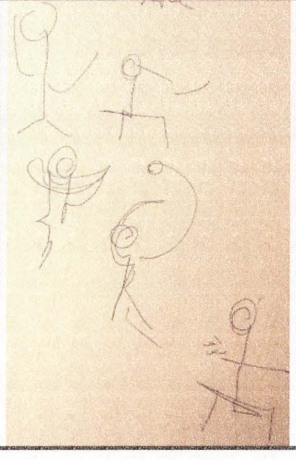
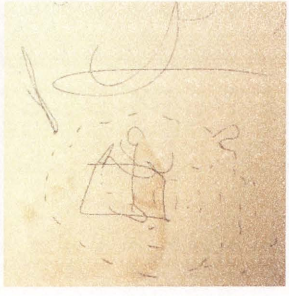
Table 6.4: Dancer 8's drawings

Visual image (early drawing)	Experience of Performing (early drawing)	Experience of Performing (later drawing)
		

This is the drums [pointing to the 3 stick figures in the drawing on the left]. *We were kinda in a circle outside in the dance* [pointing to the curved line on top in the middle drawing]. *I was going backwards and forwards and I need to go back and I was dancing it.* [Arrow in middle drawing]. *I can feel the people standing here, because I can hear them. I do the movement and it feels like I am turning all the time.* [Small circles in middle drawing] *That is why I drew this circle. Only the movement walking back felt clear.* (Dancer 8)

Dancer 1 performed a piece she was preparing for an upcoming trip to Senegal.

Table 6.5: Dancer 1's drawings

Visual image (early drawing)	Experience of Performing (early drawing)	Visual image (later drawing)	Experience of Performing (later drawing)
			

I was focusing on what I did, that is what I was drawing [pointing to the first and second drawing]. *It was very interesting. Here you can see the motion is different* [pointing to the third and fourth drawing]. *You notice the differences; it is all about direction and position. Here you can see the person is really going inside... the head is somewhere* [points to the fourth drawing]*.... Because of our culture, any movement you do, you do it in round, you don't go straight.* (Dancer 1)

In both descriptions we can recognise the spatial arrangement of the performers in the piece and the dancer's place in relation to the other performers. The drawings also reflect this, but rather than using representations of the performers, direction and position and space are emphasised.

The second exercise was the creation of choreographies around technology. Here we worked with the sensitising principles *tangibility, proximity, dynamics* and *body schema* both in the form of the abstract concepts (the words) and as concrete scenarios (specific technologies and situations) that embodied these aspects, for example poor mobile phone reception, microwaves, mobile phones, computers, TVs, remote controls, washing machines, CD/MP3 players and modes of transportation. The dancers were given the choice of developing their pieces around an abstract concept, a specific scenario, a technology, or focusing on the movements which are or might be used when using the specific technology. Their performances were filmed and the dancers were interviewed afterwards to describe their piece in words. See Dancers' 5, 8 and 10 descriptions of their pieces in Table 6.6 below.

Table 6.6: Exercise creating choreographies around technology and movement of technology

Dancer 5	Dancer 8	Dancer 10
I created movement out of the chair, how people sit, how they use chair, how chairs are being used that is what I thought of when I did this.	*It was experimental, it was about forms. I was pretending there was a microwave. I was going in as the food. After it is done I come out - it is boiling. It was about the forms: the plate was round, the food goes around in the microwave.*	*For example for a piece about a mobile, I would do a call - response. Narrative movement are easy movement, more like mime. A piece has a story to tell; when I choreograph an abstract piece, I get my own story out.*

The interesting aspects generated from this exercise were the way the dancers articulated their work and design process, as well as the body's articulations of the concepts. The exercise also brought to my awareness areas of overlap between the sensitising principles that I realised I needed to explore further. Particularly, it helped me clarify the relationships and distinctions between tangibility, proximity and dynamics, and how they relate to body schema. There were many performances in this period, so training sessions were focused on preparing for rehearsal. I attended both performance and rehearsal at different venues around Accra, and I also interviewed Nii-Yartey a second time.

6.2.3 The End

In May, which was my last month, the dancers had a tight performance schedule, so the day to day training mainly consisted of refinement of old pieces and creation of some new pieces for their performances. My main activity was semi-structured *closing interviews*, which I conducted with five of the dancers, three seniors and two juniors, with whom I had worked the most. In the interviews, which I conducted one-on-one with each of the dancers, we went in depth on a selection of the topics that had been the focus of the study (as described in Table 6.2). We focused on the following topics

- Different ways of *doing* movement and working with movement in different *capacities* - doing, performing, teaching movement;
- Creation of choreographies around and teaching from the sensitising principles - tangibility, proximity, dynamics, body schema;
- Use of space and time when dancing and choreographing;
- How to create and convey a sense of connection between dancers;
- Properties of movement, in particular, how to work with movement to indicate where a movement starts and stops;
- Relating movement to a specific point on the body, e.g. if a piece of technology is affixed to a particular part on the body vs. the technology being in a hand or being moved around; and
- How props are used and how props influence dancing and choreographing.

These topics were generated from the observations, discussions and experiences gathered throughout my stay. They were selected as issues that I wanted to clarify or explore further for the purposes of my study. I also asked these five dancers about their experiences of being part of my research.

Overall, the outcomes of the activities conducted during the three stages of this study led me to develop new understandings of the nature of professional movement practice and properties of movement as a material for design. Next, I describe the outcomes of this study with a view to informing technology design and the study of technology use.

6.3 Outcomes: Properties of Movement and Movement as Practice

[For me, performing is to] bring into existence something that is not there already. (Dancer 2)

For a professional mover, movement practice is a coming together of skills, understanding and knowledge, to perform, express, understand, appraise and create movement. In developing an understanding of movement as a material, the properties of movement are studied and explored to gain mastery of the material. For my purposes here I extracted several issues from this study relevant to the design and study of movement-enabled technology. I discuss these under the headings:

- Properties of movement; and
- Movement as practice.

The analysis of the activities with the dancers also reemphasised the nature of my involvement and role as a researcher in this research study, highlighting methodological implications for studies of movement as a craft and reflective professional practice both in interaction design and movement practice. I return to this in the Discussion, section 6.4.

6.3.1 Properties of Movement

Certain aspects of movement tend to be more easily recognisable; this pertains both to a human observer and technology (i.e. sensors); recognisable aspects of movement can help focus the attention of a human observer and can be a determining factor for choice of technology. The different dancers had different styles and different strengths that made them stand out from each other; this could be a particular energy, smoothness in the movements, expressiveness, extensions, strength to do leaps, lifts and so on. One senior dancer stood out because when dancing, he would be very clear in his expression of *shapes*. I later discussed this with Nii-Yartey and some of the other dancers who corroborated my observation. *Shapes* were indeed this dancer's *trademark*. See the illustrations in Table 6.7 below to for an illustration of three characteristic shapes. The three pictures are from the exercise comparing visual perception and felt experience.

Table 6.7: Performing shapes, Dancer 6

Shape 1: Push and Pull	Shape 2: Extending	Shape 3: Extended
		

Shapes as recognisable features of movement are interesting as they illustrate not only aspects of quality of movement, i.e. how a movement is performed, but also *positioning in space*. This aspect of human movement is fairly easily detected by current technology without very sophisticated and expensive equipment. Qualities of movement, for example, subtle or rapid movement, have been harder for technology to capture (and interpret) until recently. However, technology is becoming increasingly better at recognising and using qualities of movement for interaction, for example, the Nintendo Wii™ controller (Nintendo 2006).

For interaction with technology which is enabled through movement of the body, there needs to be some indication (i.e. user initiated or otherwise) of when and where a movement starts and stops. A sensor has to know what it is supposed to sense. When I asked the dancers to explore this they emphasised *transitions* as ways of making this change clear,

> *Transitions are important, they can be abrupt and gradual and you can freeze movements.* (Dancer 6)

Technology works quite well with static positioning in space, for example, when and where a movement starts and stops. Static positioning was explored both as a time and space based feature by the dancers. They pointed out, that in the performance of transitions, both *path* and *direction in space* are important, specifically

> *...which part of the body is leading the movement* (Dancer 10)

This could be exploited in interaction design. The part of the body which is *leading the movement* could be the part of the body where a piece of technology is positioned,

for example, wearable technology. A sensor will then know where movements originate and to where subsequent movement will need to be related back.

Understanding and Using Space and Time

Recognisable features of movement such as positioning, path, shape and direction are results of a certain use of space. Speed and rhythm, other recognisable features of movement, are time-based; transitions can *travel* in both space and time. As such it could be said that choreographing and dancing are about producing and performing both time and space, it is about understanding the properties of movement in space and time.

The dancers and I discussed the issue of the use of space extensively, both the use of space when dancing alone and when dancing with others. In both cases, space is used deliberately. Both the space and other dancers in a space are *physically addressed and interrogated.* By *addressing and interrogating* space, I mean the way dancers purposefully work with a space available to them, with props and other dancers, in the creation of a choreography and when improvising. The idea of *addressing* space can also be related to the framework developed by Bellotti et al. (2002) for sensing systems. One of the suggestions they made was for designers to consider how a user is able to address or communicate with a system, adding that this is especially important to consider in the absence of a GUI.

Several dancers spoke about the role of the music in their use of space,

> *The music gives you the feeling. (Dancer 1)*

When asked to explain further, Dancer 1 said that the music guides the way you perform your movement as well the way you will use a space. I interpret this statement to mean that the music in dance and choreography creates space in a similar way to how music (and the other props) is used to create space in the establishment of the Roda for the performance of the game of Capoeira, discussed in Chapter 5. In Capoeira, the prop, music, instruments, uniform, the other capoeiristas, are all integral to the game. They are necessary to establish the Roda as both the space and event for the movements to have their meaning for performance and for the game.

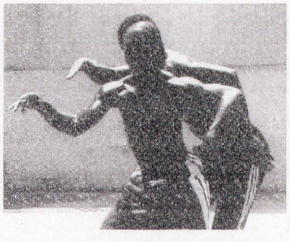
When dancing alone, the use of space is a choice of confining the dance to a small area or using as much of the stage as possible. Though, when dancing alone it is

important to *keep the base* and to come *back to the same basics* (positioning in space), said Dancer 10. When dancing with others, the dancers employ different techniques to create a sense of connection between dancers and to communicate to the audience which dancers *belong* together. Dancer 8 described space and proximity on stage as *layered* space,

> *It's layered. Space can be very far, closer and close. (Dancer 8)*

When dancers are far away from each other, one way to create this sense of relationship is by *performing as twins* or by mirroring movements, the same body part, effort expenditure, shape or movement paths in space are performed at the same time or in the same direction. For example a large movement is copied or the large movement is performed as a smaller movement or repeated with a time lag by the other dancer(s) in a repeat-follow or a dialogue type sequence. See Table 6.8 for examples of mirroring movement using the same or different body parts, similar effort expenditure, shape, direction and so on.

Table 6.8: Mirroring movement producing and performing space and time

Direction and effort expenditure	Body part, shape, direction and effort expenditure	Body part, shape, direction and effort expenditure	Body parts, shape, and effort expenditure, opposing directions
			

This can also take the form of a challenge,

> *One dancer in charge, because someone has to start. The person in charge gives the rhythm. If one dancer falls down, we all have to fall down.* (Dancer 8)

Movements do not have to be synchronous. Time and timing can be used as a *constant* or a *contrast* (Dancer 10). The rhythm of the music can also be used to establish the point from which to generate a point of contact, for example, by stamping. Other ways to establish this contact could be by facing each other, even if far away, to establish eye contact, or moving in the same direction. Turning one's backs against each other is also a way of expressing a connection or rather a lack thereof.

> *...with proximity the effects are further away. With physicality and tangibility the dancers have to be close.* (Dancer 10)

When the relationship is closer, dancers can breathe together, and when within reach, touching is often used as a way of establishing contact. In a piece, the dancers can, for example, be seen *pushing and pulling* to communicate a sense of supporting each other. At this closest *layer*, touch (tangibility) is an important indication of connection and also a necessary ingredient of using props.

As such, it could be said that for choreographers and dancers, understanding properties of movement means understanding and being able to create and use movement in time and space.

6.3.2 Movement as Practice: Understanding, Creating and Appraising Movement

Dancing and choreographing are about more than *just* performing space and time. There are emotions and stories that the dancer and choreographer want to explore and communicate. As Dancer 9 said,

> *You are supposed to fetch water, not splash water.* (Dancer 9)

This example was used by one of the senior dancers to illustrate his point in a discussion of *bodily literacy* and expression when dancing. He was referring to the activity commonly observed in Ghana, that of people carrying a bucket of water on their heads. If a dancer is performing a piece that involves carrying an imaginary bucket of water on his/her head, but the dancer moves in a jerky manner, the dancer would not be performing this piece convincingly, because it would look as if the dancer was splashing water! When a dancer performs a piece about fetching water, a microwave or the subway in Paris (examples provided by the dancers), s/he is enacting meaning through movement. By communicating meaning s/he is creating an *action-image* of the situation s/he is performing, and this has to be done in a convincing manner. (The dancer mentioned that they used techniques from acting to conjure up a particular emotion in order to convey emotion through movement.) As a professional dancer, it is not enough to be able to perform movement and express the intended story with the intended emotional content,

> *We have dancers who can do movement and dancers who can create movement. We have normal dancers, they are good, but there are only some dancers who can create movement.* (Dancer 6)

From this quote it might seem the pinnacle is to be able to *create* movement. However, mastering the opposite is also part of the vocabulary for a movement professional,

> *Sometimes they have us practice, they say "take physical expression out, don't think about the movement." That is the hardest thing to do, just doing movement on reflex; as a dancer you want to express, you want to create nice forms.* (Dancer 8)

Furthermore, a comment by Dancer 6 illustrates yet another nuance:

> *The new boys know how to dance fast and hard, but they need to be able to dance fast and soft*[3]. (Dancer 6)

From my experience working with Labanotation (Laban 1971, Hutchinson 1977, Bartenieff and Lewis 1980) I understood what he meant, but it was not something that had registered with me when observing the *new boys*. It was not until Dancer 6 demonstrated that I really started noticing this point of difference. The distinction between dancing *fast and hard* and *fast and soft* was a level of expression *the new boys* had not yet mastered, and that I was just learning to recognise.

I identified the distinction between the ability *to do* or *perform* as well as *recognise* as part of the nature of bodily knowing and understanding in Study II. In the second study, the ability to recognise was identified from working with the *instructors* and their articulations of the need to be able to recognise the execution of good, bad and stellar performance. Working with professional movers (the dancers) in the third study reinforced the importance of the ability to *recognise* as part of the nature of this type of knowing both for performers and instructors of movement. For the dancers, the ability to understand the properties of movement and be able to use these to create movement was, for them, an expression of the difference between a good dancer and a dancer who is also a good choreographer. This highlights the gain to be had from working with professional practitioners as well as amateur movers.

[3] "The new boys" refers to the two dancers that joined Noyam in my last month there.

6.4 Discussion and Reflections

So far this chapter has reported my findings from the time I spent with the Noyam Dance Institute, gleaned from the dancers' reflections, my observations of their practice and my own reflections and experiences. As a study within the area of technology design and the study of technology use, this raised certain procedural as well as methodological issues. In this section, I discuss and reflect on these issues related to the approach I employed, including the nature of my involvement and the multiple perspectives used. This becomes important in how the study was carried out, the analysis that was conducted and the theories that are developed in Chapter 7.

As stated above, the nature of my involvement in this third study (similar to Study II) was such that my observations and experiences were intertwined with the participants' articulations and demonstrations of their experiences of learning movements. My regular presence in the activities enabled an ongoing dialogue and collaborative process between the dancers and myself about movement and bodies that could define my role as an *apprentice*, a *collaborator* and as a *catalyst* for reflection.

In their book, *Technology as Experience*, McCarthy and Wright suggested that *...it might be risky to address individual sense-making processes apart from the whole,* though they also say that, *in our experience it is the only way to render this work practically useful for talking about technology as experience* (2004, p. 124). I highlighted the same issue in my Methods chapter (Chapter 3, section 3.6.2) by discussing the possibilities that multiple perspectives allow for in a study of this nature. What McCarthy and Wright call *individual sense-making processes as part of a whole*, I consider by bringing together the different perspectives of the *perceiver* and the *perceived* in developing my concepts, interrelated with my own experience.

Procedurally, in conducting this study, I drew on techniques and approaches from HCI, as well as work in areas such as ethnography, dance and movement studies. Initially, my observations and recordings were guided by trying to capture as much information as possible. Later on in the process, I would focus on particular aspects directed either by the activity I was running or aspects that had caught my attention. This could be the way a dance piece used the available space, how lifts were used to create a sense of extension, a particular dancer's style and so forth. As previously

stated, this approach was inspired by Jordan (1993) among others, who suggest a person, place, object or process focus for ethnographic observation.

The study was successful in that it triggered reflection in both the dancers and in the researcher. Although some of their reflections were outside my *grasp* (verbally and bodily), I was told that the dancers had continued discussing some of the topics I brought up on days I was not there. There is room for improvement in the means used to capture the dancers' reflections when I was not present. One way of dealing with this could have been to give the dancers diaries to use for notes and drawing, more frequent interviews, phone calls or audio recorders for self recording to capture reflections as things came to minds. Initially I was also planning to capture data in the form of occasional brief written reflections. Fortunately, I was made aware that not all the dancers could write, so I ended up relying on drawings, audio recordings and my notes without the diary component. I did not find a good replacement for these occasional reflections. A related issue is whether I should have used a translator. Arguments for this are that the dancers would have been able to express themselves in a language more familiar to some of them than English, and I might have been able to gain more nuanced verbal articulations. Also, had I been more fluent in one of their languages, I would have been able to understand what they were saying when practising; during practice they would speak a mixture of Twi, Ga and English. (Twi and Ga are both local languages; I speak only basic Twi). On the other hand, by introducing another person, I would be one more step removed from the dancers, as well as having to find and train an appropriate person. In the end, given that the focus of the study was on movement and that verbal descriptions were only one of several *lines of data* (the dancers' thoughts, experience, reflections and movements, as well as my thoughts, experience and reflections, observations and movement), I decided to forego a translator.

The material (conversations, observations, interviews etc) in this study was collected and documented as notes, audio files, digital images and occasionally digital video. I would have liked to be able to video record all the sessions, but that would have made me appear behind the camera (lacking a tripod), which is not agreeable with wanting to participate more in the ongoing activities (see below). Video recordings would have allowed me to do more detailed and comprehensive analysis of the development of

different pieces, and the dancers' development over time. If I were to do a similar study in the future, I would try to be an even more active participant, even if that would make observation and recording more difficult. The noticeable effect of openness and trust that I experienced when I increased my participation was well worth it. About halfway through my stay, an American dancer and choreographer taught at Noyam for a few days. He encouraged me to participate in entire sessions[4]. Afterwards the dancers said, *You were dancing!* and *It was good that you did it.* I think I earned a bit of respect for my participation (and maybe for my performance!). I also attended and enjoyed the vast majority of their performances while I was there. This gave me the opportunity to observe the pieces I had observed at rehearsals, performed in costumes, with an audience and the correct music. During practice they would sometimes train without music or with different music, to practice a particular sequence or rhythm.

Reflecting over the time I spent at rehearsals and performance with the dancers at the Noyam African Dance Institute, I realise that I had the privilege of being exposed to a group of very talented movers. Working along the intersection of interaction design and dance with methods from both (e.g. scenarios and improvisation), being present to observe the dancers as they were performing their practice as well as experiencing the outcomes of my activities, was inspiring and enabled me to reflect on and evolve my understanding of movement and movement practice. I also came to realise the limits of my understanding and differences between my and the dancers' understanding of movement. Where the strength of my ability might lie in being able to relate and apply a developing understanding of movement to technology design and the study of technology use; the Noyam dancers have a much more nuanced eye and an altogether different level of sensitivity and sensibility about movement. However, as Bateson noted about artists,

> *...practice has always a double effect. It makes him, on the one hand, more able to do whatever it is he is attempting; and, on the other hand, by phenomenon of the habit formation, it makes him less aware of how he does it* (Bateson 1972, p. 138)

6.5 Conclusion

In this third study I worked with professional movement practitioners with the aim of furthering my understanding of movement as material for interaction design. In doing

[4] Usually I would participate only in the warm up, then withdraw until I would carry out my activities.

so the study informed my understanding of both properties of movement and movement practice. In the study, dance and choreography functioned conceptually as a constructive arena to rethink possibilities of interaction design. At the end of this research I am comfortable stating that interaction and interaction design can quite productively be thought of as a form of movement art, and that interaction design as a craft should consider movement as one of its materials for design. Using skilled bodies in the design process places considerations of movement and interaction options at the centre of the design process. Movement understandings that are very hard to capture in words or on paper can be captured by a skilled, sensible body. This indicates an opening in interaction design for further work on tools to visualise and manipulate these types of design representations. It also highlights the need for interaction designers to learn to trust their bodies, to dare to be expressive in designing from the experiential.

In Chapter 2, I used the structural form of Labanotation (Hutchinson 1977) to describe movement in terms of *the body and its parts, space, time and dynamics*. I also proposed *tangibility, proximity, dynamics* and *body schema* as sensitising principles for interaction design focusing on movement and kinaesthetic and proprioceptive experiences. From the study presented in this chapter I have focused on a few properties of movement, that is, recognisable aspects of movement and use of space, time and dynamics, for example, shapes, transitions, layered space, effort expenditure, that became apparent from this study. In both movement practice and for the interaction design practitioner who wants to work with movement as one of her/his materials for design, it is important to develop a sensibility for these. In my opinion, they are also easily accessible points for interaction designers with varying levels of familiarity with movement.

From the three studies I now proceed by refocusing on the four sensitising principles - *tangibility, proximity* and *dynamics*, combined with Merleau-Ponty's concept of *body schema*, these became the points from which I developed the *feel dimension*, movement understanding as a design (sens)-ability in interaction design and the design questions that are explored in the next chapter.

Chapter 7
Articulating Kinaesthetic and Proprioceptive Experiences as an Experiential Quality in Interaction Design

The aim of this thesis is to develop understandings of kinaesthetic and proprioceptive aspects of interaction with technology. In this chapter, I present and discuss the main contribution of the thesis, the empirically grounded concept, the *feel dimension* - an articulation of the role our kinaesthetic and proprioceptive senses play in experiencing technology interactions from the point of view of people moving and acting. The feel dimension is described in terms of its theory, implications for practice and tools for practitioners.

> *Don't think beauty in appearance, think beauty in interaction.* (Djajadiningrat et al. 2000b, p. 132)

> *One of the key elements in professional design ability is assessment, i.e. judging how "good" a design idea is... experiential qualities are concepts that professional designers can use to develop their assessment skills and hence design better products.* (Löwgren 2007b, p. 1)

The aim of this thesis is to develop understandings of kinaesthetic and proprioceptive aspects of interaction with technology. That is, to provide a fuller understanding of user experience by focusing not just on *how* an interaction might *look*, but also on *how it might feel* to interact with technology. In this chapter, I define the experiential quality, the *feel dimension*, to describe the kinaesthetic and proprioceptive experiences of an interaction with technology. The *feel dimension* of technology interaction is an articulation of the role our kinaesthetic and proprioceptive senses play in experiencing technology interactions from the point of view of people moving and acting. It provides a conceptualisation of how bodies relate to the spaces they move in or move through, to the objects and tools in that space and to other bodies. The feel dimension is about the dialogue between people and technology/things and the qualities of this engagement.

Further, I suggest understandings of movement as a design (sens)-ability in interaction design as implications for practice for interaction designers who would like to incorporate considerations of kinaesthetic and proprioceptive experiences into their designs. This is followed by a set of suggested questions to help designers work with the experiential quality of the feel dimension. The conceptualisations of the feel dimension, their implications for practice and the design questions they raise provide the structure for this chapter.

7.1 How the Concepts Developed

The *feel dimension* and understandings about its implications for practice developed over time in an iterative cycle between reviews of the literature, bodily engagement, the three studies (Chapters 4, 5 and 6), and evaluations of, and reflections on, different systems and designs. The resulting concepts are, therefore, the synthesis of my research, as well as my interpretations of the work I have encountered by other researchers and designers.

7.1.1 Inspiration and Insights from Literature

In developing my concepts, I am particularly indebted to Svanæs (2000) for his demonstration that a study of the kinaesthetic is a valid investigation in HCI. In his thesis, he emphasised the importance of rediscovering what he called the *lost* feel dimension. In my work, I have tried to extend this aspect of Svanæs' work and to explore and articulate its relevance to interaction design. The concepts presented here are also inspired by Löwgren and Stolterman's *Thoughtful Interaction Design* (2004); Löwgren's (2007a, 2007b and 2009) work on experiential qualities; and McCarthy and Wright's (2004) *Technology as Experience*. However, where Löwgren and Stolterman (2004) and Löwgren (2007a, 2007b and 2009) mainly focused on the designer and McCarthy and Wright (2004) mainly focused on the experience of the person interacting with technology, I have tried to draw on both of these perspectives in attempting to understand the kinaesthetic and proprioceptive experiences of interaction with technology.

In Chapter 2, I describe Merleau-Ponty's *body schema* as that by which we organise our perceptions and actions, and as a background to our capacity to organise our bodily movements. In the same chapter, I also extract *tangibility*, *proximity* and *dynamics* from the literature as sensitising principles that seem relevant for an understanding of kinaesthetic and proprioceptive aspects of interaction with technology. Through my studies, further reviews of the literature and exploration of other technologies, these four principles (*tangibility*, *proximity*, *dynamics* and *body schema*) were found to be constitutative of our kinaesthetic and proprioceptive experiences and hence important for a more complete understanding of our interaction with technology and overall user experience.

7.1.2 Understandings and Insights from Studies

I used the sensitising principles - *tangibility*, *proximity*, *dynamics* and *body schema* - in Study II to understand what they mean for a fluent movement interaction and how they influence peoples' experiences of props during movement. In the activities I developed for the dancers (Study III), I used the understanding about fluent movement experiences from Study II to understand how to work with a fluent movement experience and how to design for these kinds of experiences. From these studies, I developed insights into how our bodies establish relationships with space and things in the space around us.

7.1.3 Insights from Interaction with Technology

As I lived this thesis, I continuously tested my developing ideas and understandings on systems I encountered. The smoothly operating paper towel dispenser mentioned in the Introduction (Chapter 1) was one of these systems. With this particular dispenser, the dispensing of paper towels is a simple interaction and it is immediate and smooth. Experimenting with Jin Moen's Bodybug® (2007) was another important experience. As the body moves, the Bodybug® moves up and down a wire attached to two different points on the body. The Bodybug® interaction has tangible elements, as the wire and device touch the body, although the interaction itself does not require the use of the hands. Similarly, participating in Lian Loke's study on accessing new bodily experiences through the act of falling (Loke 2009), Lizzie Muller's prototype focus groups for interactive artworks (Muller 2008) and other interactions, became productive places to both experience and experiment with *tangibility*, *proximity* and *dynamics* and *body schema* as they were refined as concepts in this research.

7.1.4 Overview of Concepts and Relationships

A schematic overview of the concepts present in this chapter and their relationships are illustrated in Figure 7.1 below.

Figure 7.1: Diagram of concepts and their relationships

The top section of Figure 1 defines the experiential quality, the feel dimension, that can be used to gain an understanding of the experiential quality of movement. The feel dimension of a technology interaction being designed, reflects how an interaction might feel. It is made up of three aspects: *coupling, spatial relationships* and *movement expression.*

The other two sections of Figure 1 are the practical applications of the feel dimension. Movement understandings as a design (sens)-ability are continually refined through engagement with the design questions as well as the sensitising principles and the feel dimension. The design questions can then be used to organise and support the design decisions that need to be made. The remainder of the chapter is an explanation of the concepts and relationships in this illustration. The *feel dimension* and related insights presented here are a refinement and extension of the ideas presented in Larssen et al. (2007a) and Larssen et al. (2007b).

7.2 The Feel Dimension of Technology Interactions: An Experiential Quality

Drawing on Arnheim (1977) who used a story about an observer and a point in space to describe the structure of architectural space, Svanæs explored how we could describe *interaction space* in a similar way (2000, p.215). Inspired by Arnheim and Svanæs, in Physical Exploration 7.1 below, I illustrate the feel dimension before explaining it in detail.

Physical Exploration 7.1: Feel dimension and kinaesthetic and proprioceptive perceptions

> In order to isolate the feel dimension within the body, try to imagine that the kinaesthetic and proprioceptive senses are our only sense modality. To perceive or experience anything we have to move or be touched. Further, if we do not know what kind of body we have, we have to move to discover this as well. To perceive, we have to act. To perceive is to act.
>
> In a world where the feel dimension is our only sense modality, aspects of technology interactions are now based around what happens when our *bodies couple with things* or *space*. In the process of incorporating things into our bodily space, there is a *dialogue* between our perception and the thing, which is enacted as a change in our *potential for action*. In this *dialogue* we are monitoring what it feels like for the body to do what it is doing. This is similar to any learning process in which we try out what something feels like, the buttons on a friend's new mobile phone, a new stethoscope or a tennis racket. It is a process of constant monitoring how it feels to do what we are doing, trying out and evaluating different feelings and measuring the effect of those feelings as actions in the world.
>
> *The feel dimension of technology interactions is this ongoing dialogue*. It is a dialogue where movement is the mode of communication. In a movement dialogue, there is an encounter of a willing mover and an inviting space in which to move.

The *feel dimension* of technology interactions is the process of establishing relationships with the space and the things in the space around us using our kinaesthetic and proprioceptive senses. As noted by Merleau-Ponty (1962), whether we feel *with* the stick or feel the stick *itself*, depends on our way of incorporating the stick into the movements of our lived body. It is about the *dialogue between people and things* and the *qualities* of this engagement. In the next sections, I describe the feel dimension by introducing three aspects that make up the experience of kinaesthetic and proprioceptive fluency, or effortless mastery (as described in Chapter 5). The three aspects are:

- Coupling, which describes how coupling with things changes our potential for action in the dialogue;
- Spatial relationships, consisting of within-reach and out-of-reach, which are about the spatial relationships between our bodies and things in space in the dialogue; and
- Movement expression, which describes how movements are used in the body-thing dialogue.

The *feel dimension* refers to the dialogue between our perception and the things we are *establishing* a relationship with. We are, through our kinaesthetic and proprioceptive senses[1], in dialogue with all the things we interact with. Different things engage us in this dialogue in different ways; things are tools of/for perception or objects of/for perception. Merleau-Ponty used the example of the stick (1962), while Heidegger used the hammer (1962), to describe this relationship defining the stick or hammer as an extension of the body. The stick or the hammer is an *extension* we act *through* or when the relationship breaks down, act *on*.

Pilates and yoga, two of the activities in Study II, have a somewhat similar focus on enabling management of one's own body, and the way the things are used in these activities supports this aim. The things or props used in Capoeria are also integral to the activity of the game, but in a less explicit way in relation to the kinaesthetic and proprioceptive senses. The analysis of the data from the second study recognised that things were experienced as *extensions*, as in the now popular example of the blind man's stick (cf. Merleau-Ponty 1962). However, this notion did not seem to cover entirely the experience described by the participants. This was particularly relevant for the way things were used among the yoga and Pilates practitioners. Rather than being described as an *extension* of the body, the things used in yoga and Pilates were described as *accessories, aids* or *mediators* with purposes such as providing feedback to create awareness, extend reach, lengthen, take weight/pressure off, isolate/access specific muscles, or enable connections between parts of the body. These experiences differ from the experiences of an extension as described by Merleau-Ponty and Heidegger. It was the process of trying to understand this experiential difference that resulted in my suggestion that props used by movement practitioners in the disciplines studied can be another type of extension.

The nature of this experiential difference (from the stick and hammer) described by the participants seemed to lie in the way in which we attend to a thing when establishing a relationship. This experiential difference arises out of my particular perspective as a researcher in interaction design, which is different from Merleau-Ponty and Heidegger's motivations. My perspective is one of making suggestions for technology design based on phenomenological accounts of the experience of things

[1] The haptic sense is also relevant here, but I will remain focused on the kinaesthetic and proprioceptive senses.

and establishment of people/thing relationships. From the insights gathered from my studies, combined with Merleau-Ponty and Heidegger's insights, I describe four aspect to explain the experience of extensions. I believe the four aspects below explain this experiential difference, and that they are experientially distinct.

> *Orientating to the thing.* Very quickly we *orient* ourselves to the thing. At this point we might not even have touched it, but based on our prior experience we make a judgement about the thing, i.e. how heavy it is, how we can pick it up, how we will be using it and so on.
>
> *Attending to the thing* and *acting on the thing.* This is when we are very much aware of a thing, when we are new to the thing or the hammer breaks. We are focusing on the thing itself; it is present-to-hand.
>
> *Acting through the thing*: The thing has become an extension of the body. In our activity we are unaware of the thing, we are acting through the thing to complete our activity; rather than attending to the thing, we feel the end of the stick or the tennis racket; they are ready-to-hand.
>
> *Attending to and acting through.* We are aware of the thing, but it is not our focus of attention. The thing allows us to focus on something else, it has become a mediator. This is how some of my participants described their experience of things in yoga and Pilates.

This fourth experiential aspect, *attending to and acting through,* is important, because this kind of relationship could lend itself to a *bodily standing back*, allowing for reflection and learning. As described in the studies, movement practitioners used props to inform and improve their movements. The fourth aspect is similar to that put forward by Polanyi, who coined the term *tacit knowledge* (1983) to differentiate the elements of tacit knowing, knowing as involving connecting two entities tacitly - that *from* which we attend (such as our sense of music or pressure of the muscles in our fingers), and that *to* which we attend (playing a simple tune).

In each of the three experiential aspects of the feel dimension, the experience is that of an interplay between our bodies and the world available to us, where our bodies are engaged in a dialogue with the thing, allowing and enabling certain couplings and making others more difficult, while changing our potential for action. Coupling (section 7.2.1), the spatial relationship between our bodies and things (section 7.2.2) and movement expression, which describes the movements used in this dialogue (section 7.2.3), are described below. In the remainder of this section I articulate the role these elements can play in our thinking about, and exploration for, technology interactions that are *tangible*, take place in *proximity* to the body and have *dynamic* aspects as understood through Merleau-Ponty's *body schema*. The elements are all

interrelated, aiming to address different aspects of the feel dimension. The experiential quality of kinaesthetic and proprioceptive aspects of interaction with technology then becomes the means by which, and ease with which, we conduct this *movement conversation*.

7.2.1 Coupling with Things and Potential for Action

Coupling is about how our bodies couple with things/space and how this changes our potential for action in the body-thing dialogue. If considered from the point of view of a thing, it is about the way in which a thing allows itself to be coupled with (or not), enabling certain couplings and making others more difficult. This results in or is enacted as a change in our potential for action. Our potential for action is made up of what we want to do and the kind of body we have. Different bodies have different sets of movements available to them in relation to a thing. People's movement possibilities are based on their bodies, experiences and skills. Factors such as different types of clothing, use of tools, the setting one is in, also give rise to different movement possibilities and hence different potentials for action. When we move in a body-thing couple, we couple our movement possibilities to the thing's movement possibilities and feel the consequent change in our potential for action. When we move freely (e.g. dancing alone or couple with something very light, like a feather) we can feel only our own movement possibilities. When we move in relation to a thing (e.g. play an instrument) we can feel properties of the body-thing couple, we can also feel properties belonging to the thing, as well as our own potential for action. For example, if the power cord on your laptop is caught somewhere out of sight, we can get a sense for how close or how far away the cord is caught by tugging lightly and maybe flicking it. This will give us a sense of both our own movement possibilities, those of the cord as well as the potential for action between ourselves and the cord.

7.2.2 Spatial Relationships

Our actions unfold in space organised by our intentions. Our actions in space are about the spatial relationships between our bodies and things in the body-thing dialogue. In the process of incorporating things into our bodily space, there is a dialogue between our perception and the thing, which is enacted as a change in our potential for action. As described in section 2.2.3 (Spatial Perception and the Body as Our Point of Reference when Moving), space can be organised into several co-existing spaces; e.g. *personal*, *extra personal* and *far space* (Berthoz 2000, p. 98).

Integrating with these spaces are the spaces within which we act in relation to other people, to things and social aspects. All of these spaces act as references for how we use movement to organise perception and action.

The ways in which a thing allows itself to be coupled with (or not) within these co-existing spaces give rise to a differentiation between *within-reach* and *out-of-reach* actions in space. These two terms are not to be taken in a purely physical sense; the *feel dimension* of technology interactions is based on whether our actions are having the desired effect in the world, not only in terms of being within-reach or out-of-reach in a physical sense. An interaction can be out-of-reach due to *physical constraints* (e.g. shape, weight etc) or *cultural/social constraints* (e.g. inappropriateness, awkwardness, shyness etc).

Within-Reach

Interactions taking place *within* bodily *reach* are characterised by the fact that they are taking place on, near or fairly close to the body. Examples could be wearables that we feel as weight or pressure on our body, tangible interactions such as moving tagged objects in an augmented reality environment, moving a can of beans with a RFID tag near a cash register or skipping to the next song on the MP3-player in our pocket. Wearables and wearable structures can be seen as tangibles as they also address our kinaesthetic and proprioceptive senses by changing our sense of weight, relative position and the scale of the body (relative size) by influencing our paths in space, use of force and centre of attention. Within-reach interactions are also those that would not normally be possible, but that are enabled through the use of another thing (e.g. a remote or a crane to lift a container), or interactions that would be understood in a certain context (e.g. a gesture to a sensing system). The commonality is that the thing allows us to couple our movement possibilities with the thing's possibilities and have the desired effect in the world.

Out-of-Reach

Interactions that are *out-of-reach* are out of reach either due to physical constraints (e.g. automatic door), cultural/social constraints (e.g. self-flushing toilets) or both (e.g. technology's lack of understanding of context). These interactions tend not to have tangible elements, and positioning is an important aspect of out-of-reach interaction. The interactions depend on a user's position and/or location sensed by either

stationary or moving technology located in the environment. In a museum with an automatically triggered audio tour, trying to find the position to trigger the correct recording can sometimes be a challenge and take up more attention than looking at the exhibits and listening to the recording.

The Relevance of Touch to Within-Reach and Out-of-Reach

Technology interactions can, of course, consist of both tangible and non-tangible elements. For the *feel dimension* there is a distinct difference between things we can touch and those we cannot touch. Things we can touch can be experienced, and hence interacted with, in ways different from those we cannot. This is because with things we can handle we can *couple* our *potential for action* with the thing's movement possibilities and feel the subsequent change in our potential for action. A thing that we cannot couple with provides less information about its, and therefore our, potential for action, through the *feel dimension*. Whether something can be touched or not might seem to be the major difference between *within-reach* and *out-of-reach*. It is not. The difference, as pointed out by Hornecker and Buur (2006), lies in whether our actions are having the desired effect in the world. If particular spatial relationships mean that no coupling is possible, there is less room for us to engage in a dialogue to establish the body-thing couple through the *feel dimension*. Hence, the thing then needs to provide additional information to compensate for this (e.g. through another sense).

7.2.3 Movement expression

Movement expression refers to the way in which we execute a movement to establish a coupling in an interaction, whether the interaction is happening within-reach or out-of-reach. Experientially, this can be described in a continuum of intensity, from the reach for a cup to a straight punch: reach, stroke, contact, seize, push, strike, punch and so on. I describe this in section 4.2.4. For example, when interacting with the Eyetoy® (Sony 2003) the way in which a movement is executed does not matter to the technology (Loke et al. 2007). However, the dynamics are very much relevant as part of fluent kinaesthetic and proprioceptive experiences as described by the participants in Study II. In interaction with the Eyetoy®, the fact that the sensors do not detect the dynamic aspects of movement is an advantage as it allows people to interact with individual movement expressions. A kiosk with a touch screen in a public space should be designed so anyone can walk up to it and start using it.

However, systems which will be used over extended periods of time and require some effort to learn could be designed to capitalise on individual movement expressions.

To our bodies, the way in which a movement is executed always matters. There is always an intentional purpose for our movements for perception. To technology, movement expression matters only sometimes. Whether it matters for individual projects should be based on considerations such as tasks, target users and context of use. However, the degree to which movement expression in technology interactions should be choreographed is a significant ethical issue which needs to be considered carefully by technology designers (Robertson 2006).

7.2.4 Summary: The Feel Dimension

Things, including technology, engage with our physicality. This section describes the *feel dimension* as an experiential quality that engages our bodies and things in a particular kind of dialogue. It introduces three aspects that were extracted from my studies and the literature using the perspective of technology design. With the feel dimension, I am not seeking to contribute a design method, but an experiential quality and a set of aspects that together can act as a conceptual tool to help us understand how a technology interaction is experienced at the kinaesthetic and proprioceptive level. This is to contribute to the understanding of kinaesthetic and proprioceptive aspects of interaction with technology, and expand our understanding of user experience. As such, the feel dimension then is not as much about categorising as sensitising to a particular perspective.

Other researchers in HCI have theorised and conceptualised the relationships between people and technology at this level, for example Svanæs' work on *kinaesthetic interaction* (2000); Hummels who used the term *aesthetics of interaction* to describe *the sense of beauty which arises during the interplay between a user and a product in their context* (2000, p. 55); McCarthy and Wright's explorations of *felt-life* (2004); Löwgren's aesthetic quality *pliability* which he describes as an interaction that is interesting in a tactile way (2007a); and Loke's methodology of *Moving and Making Strange* (2009). Outside, yet relevant to HCI and my research, is work coming out of the study of clothing and fashion. Banerjee and Miller suggest that clothing as a collection of ideas worn on the body needs *to feel right* (2003). Considering the intimacy of clothing as a boundary between our bodies and the world, we can see that

this would be immediately relevant to wearable technology, which is a function of fashion and social considerations as much as anatomy. However, it is as relevant to movement enabled interactions and the feel dimension considering the intimacy of movement as an *interface* between our bodies and the world. (Consider also my earlier claim, section 2.2.1, Physical Exploration V, about the social function of movement).

The feel dimension has described the kinaesthetic and proprioceptive experiences of interacting with technology from the perspective of the user or mover. I now continue to describe the implications for practice and some possible tools associated with kinaesthetic and proprioceptive experiences as an experiential quality to support interaction design practice.

7.3 Movement Understanding as a Design (Sens)-ability in Interaction Design

My findings from the studies, particularly Study II and III, suggest that the movement experience of the knowing required and involved in doing, performing and working with movement is a knowing *how* and that this knowing is *felt* and *achieved* through moving. The performance of the bodily practice is the way to display this knowing experientially. This section describes what it could mean to pay attention to kinaesthetic and proprioceptive experiences as an experiential quality for the practice of interaction design. In section 7.4, I expand on some considerations that can be used as tools to support discussion for interaction designers who want to incorporate considerations of kinaesthetic and proprioceptive experiences into their designs.

In the quote at the beginning of this chapter Löwgren says

> *One of the key elements in professional design ability is assessment, i.e. judging how "good" a design idea is... experiential qualities are concepts that professional designers can use to develop their assessment skills and hence design better products.* (Löwgren 2007b, p. 1)

He is arguing that experiential qualities can aid designers to develop their assessment skills. In this section, I discuss how a better understanding of movement and hence, a better understanding of kinaesthetic and proprioceptive experiences could lead to better *assessment skills* for interaction designers.

Through working with the movement practitioners in Study II and the dancers in Study III, I learned that movement practice is a coming together of skills,

understanding and knowledge, to *perform, express, understand, appraise* and *create* movement. This understanding can be exhibited in the *performance* of movement and also as a *recognition* of understanding, knowing and movement fluency in others. In developing an understanding of movement as a material, the properties of movement are studied and explored to gain mastery of the material. So *skilful coping* with movement and *skilful appreciation* of movement are core to movement practice.

But what does it mean for interaction design that skilful coping and skilful appreciation become part of the skills and knowledge of an interaction design professional? From the understandings gained from this research, it means that an interaction designer, seeking to develop skills in designing for the feel dimension, can aim to acquire skills in:

- Movement practices as a practitioner and development of the ability to perform, explore, create and evaluate movement, and
- The observation and assessments of movement performed by others.

My suggestion is that working with kinaesthetic and proprioceptive experiences as an experiential quality and hence movement as a material for design, means working with a type of knowing that is enacted in practice, not as a competence to be transferred, but to be experienced. An example of this would be Klooster's *Choreography of Interaction* methods (Klooster and Overbeeke 2005, used in the prototyping in the "Intelligent Lamp Case Study" (Ross and Wensveen 2010). As such, the building of this competence could be seen as the process of developing a designer's capacity to enact with movement under different circumstances.

7.3.1 Interaction Designers as Skilled Performers of Movement

For interaction designers to become skilled performers of movement, they need to develop the abilities to do, create and perform movement. From Study II we learned that movement practitioners at times are able to do without explicit bodily understanding because they had developed these abilities. The capacities to act that these abilities provide in those who have them, enable us to understand using and coming to develop an understanding of movement as materials for design, and hence how it would be useful for an interaction designer to be a skilled performer of movement.

As experiential bodily knowing is felt and is a *knowing how*, this means that meaning is produced in and through movement. For interaction design, this is a recognition that the only way we will have access to or know certain things is through moving, in which case interaction designers need to move as part of the process of designing; designing technologies that rely on human movement as input is about designing potentials for the production of meaning in and through movement. Similarly to problem solving in other domains, a designer/mover can interrogate and reflect on movement by doing and performing with movement. As pointed out by my study participants, the moving/doing/performing needs to be guided by something that focuses or triggers the designer's/mover's attention and awareness. This could be a structured activity or improvisation or a combination of the two. For example, designers could be guided by an improvisation activity based on a loosely related metaphor, or the movement they are trying to achieve in relation to a sensor or the place on the body where a device is located.

This is also supported by theory on reflection and practice in this area; for example Blom and Chaplin (1989) suggest that direct experience is important for tacit knowledge as it helps the body develop responses to different situations.

> *Direct experience builds a fund of tacit knowledge which becomes embedded in the body's response system. ... Besides kinaesthetic responses, there are sensations, psychological awareness and agendas, mental images, and kinetic phenomena. The resultant accumulation is integrated into each person's response system to form a unique experiential body of knowledge.* (Blom and Chaplin 1989, p. 16)

Nearly thirty years ago, Schön said that *conversation with materials* is part of current design practice (1983). Designers draw and gesticulate, among other things, as part of the process of reasoning, reflecting and conceiving of ideas. In the design studio, ideas and activities are made visible and tangible by means of physical material. A design process is often highly material, and the materials for design are interrogated as part of the process, as knowing through making. He also said, *Although we often cannot say what it is we know, we do know how to take action.* (Schön in Winograd 1996, pp. 172-173). Translated to interaction design, my suggestion is that interaction designers as skilled performers of movement could learn to *converse with the materials* and learn how to *take action* with their newfound understanding of movement. Movement needs to be interrogated explicitly, reasoned about, reflected

on and explored in a similar fashion. For Schön, the exhibition of skill or artistry as a professional is an exercise of intelligence, a kind of knowing (1987).

7.3.2 Interaction Designers as Skilled Observers of Movement

Interaction designers, as skilled observers of movement, could aim to develop the ability to observe and recognise good performance. This means to recognise understanding, knowing and fluency in other movement performers. For example, Participant 13 in Study II, both a movement practitioner and instructor, described her reaction when observing incorrectly performed movement this way:

> *It strikes a discordant note in the brain - makes me feel uncomfortable - puts me on edge. I either have to correct it or look away. It hurts my eyes in the same way a wrong note on the violin or other musical instrument is painful for the ears.* (Participant 13, Pilates instructor)

Participants in the second study described how they, over time, have come to a certain level of knowing in their practice. This is the ability to do movements as well as the ability to recognise knowing and ability to perform in themselves and others. Montero suggests that the kinaesthetic and proprioceptive senses play a role in assessment of movement as well as the aesthetic enjoyment of movement, through empathetic responses to performers' movements. She says

> *...proprioception is an aesthetic sense and that one can make aesthetic judgments based on proprioceptive experiences...just as one can deem a painting beautiful based on visual experience of the painting one can deem certain movement beautiful based on one's visual proprioceptive experience of the movement ...an observer can propriocieve the beauty of another's movement.* (Montero 2006, p. 231)

The question of whether a practitioner needs to have had the experience of a fluent experience in order to recognise it, remains open to debate. Can a person be a good swimming coach without knowing how to swim? According to my research, having had an experience of a movement, increases one's ability to perform the movement, play and improvise with a movement as well as recognise good performance of it. We don't expect brain surgeons to have had brain surgery, but we do expect surgeons to know their tools and have a good understanding of the brain. The same is the case for interaction designers. We do expect the interaction designers to know their materials as well as their tools. An understanding of the materials in movement-enabled technology design, means understanding how movement creates meaning in an interaction. This domain knowledge is necessary to make good representations, which we know are essential for interaction design.

The skills related to performing and observing movement are skills that could be suggested as being part of the *craft* of interaction design. The skills needed to be good at a craft incorporate our senses of touch, sight, hearing, smell as well as the kinaesthetic and proprioceptive senses (cf Godal's list of characteristics for a skilled craft person in section 2.2.4.). Skills related to *craft* rely on the mutual constitution of knowing and doing, that is knowing what needs to be done and how to do it under different circumstances. Using the term craft points to understandings and abilities to respond to situations with the whole body in combining skills, knowing and intuition. To do this, one has to develop the ability to name and appreciate the different dimensions of situations and experiences, and the way they relate one to another, and further enable others to see the qualities of something. Dewey (1934) also makes this point, he suggested that experienced observers, such as a critic, can identify a potential experience and discuss its character. Craft is about skilful coping or skilful interaction with some part of the environment. As discussed earlier, interaction design thought of as a craft then becomes about the craft of interaction and knowledge and mastery of the tools and materials of that craft.

7.3.3 Summary: Movement Understanding as a Design (Sens)-ability

I have argued that in order to design interactions that take into consideration the experiential quality, the feel dimension, interaction designers need to develop the ability to perform assessment on movement experiences. This skill comes from both an ability to perform movement and to observe movement. My suggestion that interaction designers can develop skills in performing as well as observing movement, means that an interaction designer who subscribes to this will design both *from* her/his own experiences of movement and *for* other's experiences of moving. As a method for studying relations of technology design and use, designing both *from* and *for* experiences of moving emphasises the importance of being aware of different perspectives – the user's, the designer's and the perspective of technology. This is suggested earlier both in the methods chapter (Chapter 3) and in the analysis of Study II (Chapter 5).

Experiential bodily knowing is felt. When becoming increasingly familiar with movement as a material for the design of technology interactions, we come to new understandings and nuances of understanding of the material. The focus then becomes

to understand the conditions under which this knowing and understanding is more or less likely to be enacted. As a method, activities that make designers and researchers move and perform movement with prototypes and artefacts while designing can open up insights into how interaction with new products, environments, or interfaces may feel to use, in addition to how they may look. It is about having empathy with a user's experiences, daring to feel and appreciate one's own experience as a designer, concretising the feeling and designing from this. In doing so, movement understandings as a design (sens)-ability in interaction design support engagement and provide inspiration.

Gibson's (1979) ecological theory of perception can be used to support this. Gibson said that the world unfolds itself in potential for action; we perceive the world in relation to what we can do with it. As the feel dimension described, things, products and spaces engage with our physicality, and movement is the material in which we engage in a dialogue with these. Because interaction creates meaning and meaning generates understanding and knowing in action, it can inspire designers to explore and design useful, usable and enjoyable interactions. As a designer, an appreciation of movement as a unique material in technology design suggests developing a sensibility for movement that is an ability to recognise one's own movement experiences, reason about how someone else would experience the use of a design, and being able to design based on this understanding.

7.4 Design Questions for Kinaesthetic and Proprioceptive Experiences as an Experiential Quality

> *When artists, designers, architects and engineers* build an understanding of the properties of a material, they often study it by creating a structured collection *of basic* examples that explore different aspects and properties of the material. *A basic understanding of the properties of, e.g., wood, paint, concrete, as materials for design, can perhaps only be achieved by working with them in practice. More systematic studies of the material are then used to map out the design space of possible expressions.* (Hallnäs and Redström 2002, p.195, my emphasis)

This quote was used to introduce Study III (Chapter 6), I use it again here as it illustrates the transition from an emphasis on movement understandings as part of interaction design practice to practical applications of this movement understanding when designing. In this section, I present a set of questions that could be used by interaction designers to *explore different aspects and properties of the material* (ibid),

in this case the material being movement. These design questions are practical applications of the feel dimension in that they provide specific ways for designers to reason about the dialogue between people and things, space and technology and the qualities of this relationship. They can be used to organise and support design decisions. The overall design question is:

> What movement and what movement relations do I choose for an interaction, and how do the choices I make affect the interaction experience in terms of the body-thing dialogue?

The way to determine this is to consider the effect of a choice on the *feel dimension* in terms of the *coupling*, the *spatial relationships* and *movement expression*. The discussion of the design questions below is structured around considerations of *what* are important aspects when choosing movements, *how* to carry out these movements to enable interaction and how this impacts on the *relationship* to sensor technologies. The questions are interrelated, in the same way kinaesthetic and proprioceptive experiences are interrelated with our overall experience with technology. The questions aim to aid designers in appreciating the subtleties of designing for the feel dimension. For the feel dimension and for each of the aspects in it, I provide questions, and an elaboration of the associated considerations, indicating the significance and implications when applying the questions. This organisation is inspired by Bellotti et al. (2002) and Hornecker and Buur (2006).

7.4.1 Feel Dimension

> What movements are being used or are being proposed to be used in an interaction, and how do the movements in an interaction allow for the *establishment* of the relationship between a user and things?

To answer this question one can consider whether the whole body or part of the body is sensed and also what part of the movement is sensed. This matters for the interaction experience for a number of reasons. If the whole body is sensed, it is likely only the presence or absence of the body in a space or time that matters, in which case there is little room for the feel dimension. However, if the movements of the body or parts of the body matter, then important issues to consider become:

- Is what the rest of the body is doing relevant for technology? Are the movements of the rest of the body considered as input, can the rest of the body

participate in the completion of a movement, or does the interaction make it difficult or awkward to perform this movement?

- What happens if what the rest of the body (apart from what is sensed for interaction) does is irrelevant? In what way does it influence the interaction? Do the movements of the rest of the body interfere? Does it mean the interaction is not enabled? Is the interaction imprecise?
- How do movements used in an interaction set the mover up for what is to happen next, i.e. the next interaction?

These considerations are important as partially sensed or incomplete movement can cause awkwardness for the person carrying out the movement and it can cause imprecise sensing. The significance for the user could be that halfway through carrying out a movement, one gets a response from technology that the movement has been sensed. At this point there is uncertainty whether to continue the movement or stop as soon as one receives feedback that the movement has been detected. Stopping without completing the movement is uncomfortable and unsatisfactory in terms of performance of movement. It also is awkward in terms of what is happening next. For the feel dimension this is as important as considerations about how or what movements the technology makes the mover perform in order to enable interaction.

As I pointed out in Chapter 5, when carrying out a fluid movement, continuity is more important than discrete moments in time. For example, in terms of space, the Roda or the props in yoga and Pilates will determine the relationship between the mover, the movements and displacement in a space. The issue that needs to be understood is how the movements performed in time and space set the mover up for what is happening next? This matters because any one movement must always be considered in relation to both the preceding and the next movement. The next is being planned while the current one is being carried out. In a fluent movement experience, the mover is in *now*, because the focus is on the movement being carried out, but what is happening now is also directed towards what is coming next.

7.4.2 Coupling with Things and Potential for Action

What movements are being used or are being proposed to be used in an interaction, and how does this affect the coupling with things and change our potential for action in the body-thing dialogue?

For physiological reasons, movements for interaction need to be considered for their appropriateness for the targeted users, in term of anatomy, experience, current ways of carrying out a task and so on. For an understanding of this aspect of the feel dimension, interaction designers could consider issues such as:

- Is the user being sensed as part of normal activity or do special movements have to be adopted to enable interaction?
- How does the design of the technology, both its physical form and sensors, determine the type of movements that can be used to enable interaction?
- What possibilities and what constraints do the sensors and the interface place on types of human movement?
- What is the affordance of the interaction?

7.4.3 Spatial Relationships

> What movements are being used or are being proposed to be used in an interaction, and how does this affect the spatial relationships between our bodies and things in space we couple with?

The spatial relationships between bodies and things are affected by relationships to space, things and sensors. Considerations for interaction designers could include:

- Is what is being held heavy or light, stationary or mobile?
- Is the user moving "free-to-air" or holding onto stationary or mobile technology while interacting?
- Is the movement taking place in relation to a fixed point on the body or in the environment?
- Is the user deliberately moving the sensor device, or is the sensor technology moving?
- Is the user willing/unwilling, likely/unlikely, comfortable/hesitant to perform movements required for interaction, and ways of carrying out those movements, in particular settings and contexts? That is, are the movements, hence the experiences, socially and culturally within-reach or out-of-reach?

These considerations have implications for the kinaesthetic and proprioceptive experiences, as they determine how the mover can couple her/his movement

possibilities to the device or not, and also the sense of control the user has in an interaction.

The aspects of within-reach and out-of-reach interactions suggest considerations in terms how close to the body a movement is taking place, whether a certain position has to be assumed to effect interaction, as well as the appropriateness of the movement. Appropriateness is relevant for the feel dimension because making people perform actions that are inappropriate, unusual, dangerous or different in other ways in particular contexts will affect people's experience of an interaction in the same way an awkward or pleasurable movement would. A movement considered for interaction might be physically possible, but the experience of carrying it out might mean the movement is socially and culturally within-reach or out-of-reach.

7.4.4 Movement expression

> What movements are being used or are being proposed to be used in an interaction, and how does this affect how movements are used in the body-thing dialogue?

The considerations to take into account here include effort expenditure and the distinctions between movement and movement quality:

- Is the user able to interact with individual movement expression?
- What kind of movement expression and effort expenditure does the interaction require?

In HCI, low effort expenditure is often the aim when designing interaction. However, low effort expenditure is perhaps appropriate for interactions where the overall aim is ease of use, but not necessarily for enjoyment of use, ergonomics or skill building. Focusing purely on efficiency of movement may cause a diminished experience in terms of the feel dimension.

In an interaction, with a thing or with technology, the effort expenditure is often mirroring or in some way related to the thing/technology. This can be utilised in interaction design by considering whether to build into the use of the technology that the movement expression is used/sensed in the same way it is expressed/performed. Examples of this could be an indication that the speed with which one moves a hand past the sensor of the smoothly operating motion-sensing paper towel dispenser

described in the Introduction, results in either quicker dispensing of paper towel or a longer piece of paper towel. This means that as interaction designers we might want to consider the choices we make about how to represent movement as well as what aspects of movement to use for as input for sensing technology.

Study I illustrated that *how* a movement is carried out matters to people, but not always to technology. For the feel dimension the *how* matters a great deal, the aspect *movement expression* refers to the way in which we execute a movement to establish a coupling with a thing/technology in an interaction. Flair and expressive movements carried out while, for example, playing an instrument or handling a tool are part of the subjective experience of handling the instrument or tool, but are also observable as part of a public performance. Bowers and Hellstrom's (2000) called this *expressive latitude* when designing and using electronic instruments.

7.4.5 Scope of the Design Questions

The questions described above are intended to aid in organising and supporting design decisions and as such can be used in both evaluation and design. They can be used to design new movements as well to evaluate existing ones. When should a designer take into consideration the experiential quality of the feel dimension? Although it is tempting to say *always*, interaction designers should at least keep it in mind when designing and evaluating movements that are used to enable interaction. When movement is the main interaction modality, these considerations should be core to design and evaluation. It is important to note that the feel dimension is not a property of an interaction itself, nor is it a psychological or physiological property of the user/mover. The experiential quality of the feel dimension appears in use. This means that as interaction designers, we cannot design an interaction *with* the feel dimension as an experiential quality. However, we can consider and design the conditions for the feel dimension as an experiential quality to appear or be addressed in the use or experience of an interaction.

Given the nature of movement experiences as described in this thesis, interaction designers need also to consider that what a movement looks like, what it feels like and the accomplishment of that movement (bodily speaking) are or can be different experiences. For interaction design this means that movement can be considered for completeness of task, that is, movement is seen as a means to an end, the movements

in themselves are not really important. However, other types of interactions, where the aim for the movement enabling interaction is on *being in movement*, not only movement as a function of doing, (i.e. a function of accomplishing a task), can be considered.

We already know from Benford et al. (2005) that movements that are used to enable interactions with technology must both be possible to perform for people and possible to be detected by sensor technology. The questions I suggest here could therefore be seen as complementary to the contribution of Benford et al. I see these design questions as a similar resource to the Cultural Probes developed by Gaver et al. (1999). The Probes were initially developed as resources for *inspiration, not information* for designers. I hope designers will think of the feel dimension, movement understanding as a design (sens)-ability and the design question as tools to develop a sensitivity to issues of movement as a material for design. That is, given an ability to recognise one's own movement experiences, interaction designers could develop an ability to reason about how someone else would experience the use of a design and eventually be able to design based in this understanding. Data gathered from a weblog or a timed recording of use of a device provides different information from a usability testing session with a participant where one can watch (and talk to the user about what they think). This again is different from engaging with movement from the perspective of the feel dimension which allows observation, exploration and engagement, at an experiential level, with how it might feel to carry out the interaction.

7.4.6 Summary: Design Questions

These design questions highlight kinaesthetic and proprioceptive experiences, and they are meant as guides that can assist interaction designers throughout the process of designing interaction where movement is a material of design. They are framed as questions to consider in the design process. The questions and the related discussions are linked to the three aspects of the feel dimension through their focus on the different aspects of the body-thing dialogue.

Designing for kinaesthetic and proprioceptive experiences is inherently ambiguous; people's movements and movement experiences are different. However, an awareness of this diversity opens up a design space where we can think in terms of how to enable

users to physically address interaction spaces, surfaces and objects; as well as giving the bodies of both users and designers, inviting movement problems to explore and engage with.

7.5 Conclusion

This chapter has presented the experiential quality, the feel dimension, by outlining its theory, potential practice and some tools for practitioners. I first reintroduced the four sensitising principles (tangibility, proximity, dynamics and body schema), and then three aspects of the feel dimension, (coupling, spatial relationships and movement expression) that were developed from the literature, my own interactions with technology and the explorations in my three studies. The chapter suggests some implications for practice and some ways in which designers could interrogate current and future systems using insights gained from an understanding of the feel dimension. As such, the implications of my findings are relevant for the design, theory, methods and implementation of systems that use the human body and its movement to enable interaction.

In the Introduction to this thesis, I stated my research question:

> *How can kinaesthetic and proprioceptive experiences as an experiential quality be accounted for in technology design and the study of technology use?*

I can now offer the explication of the feel dimension as one way in which this could happen, and the design questions as practical applications of my insights.

Chapter 8
Conclusions and Future Work

I began this thesis with the aim of trying to understand kinaesthetic and proprioceptive experiences of interaction with technology. This chapter concludes the thesis by revisiting its major points and research questions. I also give a few suggestions to indicate possible research directions in the areas of kinaesthetic and proprioceptive experiences in technology interaction and user experience.

> *There is more to interaction than meets the eye.* (Buxton in Borman and Draper 1986, p. 319)

> *Sometimes attaining the deepest familiarity with a question is our best substitute for actually having the answer.* (Greene 2003, p. 365)

In this thesis, I have endeavoured to contribute to the field of interaction design by extending the concept of user experience to also include kinaesthetic and proprioceptive aspects of the user experience, that is, to more fully understand not just *how* an interaction might *look*, but also *how it might feel* to use. In the next sections I summarise the work I have undertaken in relation to the questions I set out to address. I also indicate some directions for future work within interaction design.

8.1 Revisiting the Research Questions

The main topic of this thesis is kinaesthetic and proprioceptive experiences in the design and use of interactive technology. My research attempts to answer the question:

> *How can kinaesthetic and proprioceptive experiences as an experiential quality be accounted for in technology design and the study of technology use?*

Phrased as a design-oriented inquiry, this question could be formulated as:

> *How and what makes a technological system good to use from the perspective of the kinaesthetic and proprioceptive senses?*

That is, how can kinaesthetic and proprioceptive experiences be defined, described, analysed and represented in relation to technology design and the study of technology use? From this main question, I stated three sub-questions of theoretical, methodological and practical nature:

> *1. What terminology and what methods are available in HCI for studying movement, in general and kinaesthetic and proprioceptive experiences, in particular? (literature/theory)*

> *2. How can the role our kinaesthetic and proprioceptive senses play in experiencing interactions be accessed? (methodological)*

> *3. What aspects of kinaesthetic and proprioceptive experiences could be relevant for understanding technology use and interaction design? (design oriented/practical)*

I address the overall question and the sub-questions in the next sections.

8.1.1 Overall question

How can kinaesthetic and proprioceptive experiences as an experiential quality be accounted for in technology design and the study of technology use?

My hypothesis was that a more thorough understanding, better descriptions and representations of the kinaesthetic and proprioceptive senses would aid our overall understanding of technology designs and help us develop better, that is, more fluid, interaction experiences with technology. In response to my main question, I offer the *feel dimension,* defining the nature of the kinaesthetic and proprioceptive experiences of interacting with technology from the perspectives of a mover. It is an attempt at exploring and describing the dynamic between people and technology based on the philosophic insights of Merleau-Ponty (1962). I also suggest movement as a design sens(-ability) and a set of design questions as a practical application of this contribution. These insights were developed from understandings based in literature, my three studies and my interactions with technologies. My contributions, therefore, address our understandings of the nature of the user experience and movement as a material for interaction design. My intent was not to contribute a design method per se, but an articulation of the experiences and aspects of that experience that can act as conceptual tools to help us understand how and what makes an system good to use from the perspective of the kinaesthetic and proprioceptive senses. These conceptual tools then, are not so much about categorisation but about sensitising designers to a particular perspective. Within HCI and interaction design, I believe these can be useful as conceptual tools by providing a language for thinking and talking about kinaesthetic and proprioceptive experiences of interaction.

Sub-question 1

What terminology and what methods are available in HCI for studying movement, in general, and kinaesthetic and proprioceptive experiences, in particular?

The first sub question was addressed through a review of the literature and Study I. As outlined in Chapter 2, phenomenology informed by Merleau-Ponty (1962) determines the way I see movement, that is, as fundamental in shaping our experience in the world, our understanding of the world and our interactions in the world. Kinaesthetic and proprioceptive perception are fundamental aspects of our movements as well as our interaction with technology. They are so fundamental they are very often taken for granted, yet without them we would not be able to do much. Throughout the

development of the thesis, the ideas of Merleau-Ponty (1962) have been present by enabling a particular understanding of human movement, our experiences in space and with things in the space around us.

Three main areas of literature were reviewed for this thesis: HCI and phenomenology, different understandings of human movement and experience, and movement and experience in technology interactions. Within these I identified three different understandings of human movement and experience relevant to my research study:

- Movement as an object for investigation, considered from the perspectives of both technology and human observers;
- Movement as subjective experience, providing insights about how to access and address kinaesthetic and proprioceptive experiences; and
- Movement as a form of knowing, providing insights into the role of the kinaesthetic and proprioception experiences in doing and performing, and the relationship between knowing and doing in the performance of bodily skill.

Different concepts and theories from these areas were used for reasoning about the study of movement enabling interaction with technology and subjective experiences of movement in relation to technology. These areas were selected as they disclose different aspects of movement and allow for multiple ways to address and approach a study of movement and movement experience in relation to technology.

For the first study, I chose four frameworks from HCI. These frameworks allowed me to analyse movements and relationships between movements and technology produced in interaction with the Eyetoy™ computer game. Each of the frameworks and approaches allowed different perspectives on human movement in interaction design and addressed different aspects of the interaction as well as ways of evaluation, thus informing the study and design of movement-based interaction. The study served as a starting point for developing an understanding of movement as input for interaction in order to inform interaction design. Using findings from the study to populate existing conceptual frameworks provided me with tools to further this understanding.

The way in which current technology can sense and subsequently use movement, often relies on the *moment of interaction*, meaning that the *presence* or *absence* of a movement is what the technology really cares about regardless of how movement is carried out, how it is experienced and so on. However, in some technology interactions designed for artistic expression, the presence of a body, how a body moves, which body part moves and the experience of movement, are an integral part of the interaction. These technologies and their design methodologies often pay close attention to subjective experiences of movement, including kinaesthetic and proprioceptive experiences, of both designers and potential users as starting points for as well as inspiration, and contributions into the design process. As an additional way of focusing more explicitly on movement in interaction design, I propose the inclusion of certain aspects of Labanotation (Hutchinson 1977) in order to extend descriptions of movements as they are generally used in interaction design today.

Sub-question 2

> *How can the role our kinaesthetic and proprioceptive senses play in experiencing interactions be accessed?*

The second sub-question was of a methodological nature. It was addressed in the second study as well as discussed in the Methods chapter (Chapter 3). Essentially this question asks, how, within the fields of technology design and study of technology use, can we access and more fully understand interaction experiences, particularly kinaesthetic and proprioceptive aspects of the interaction experience, as starting points for technology design and further study of technology use. To address this question, I conducted a study that engaged the participants in movement experiences intended to trigger reflections that would enable them to articulate their movement experiences. In order to access my study participants' movement experiences, I used a combination of *movement triggers* as an elicitation technique, the collection of both verbal and bodily articulation of movement, and participant observation, to gather and analyse data about the learning of movement skills. This enabled me to access multiple perspectives on the experience: my observations of shape and spatial path of a movement, and each practitioner's bodily articulation, as well as each practitioner's verbal articulation of the movement experience. I identified and described a fluent kinaesthetic and proprioceptive movement experience as one of effortless mastery.

A second question, about the *nature* of experiential bodily knowing and understanding generated through experiences of moving, was also explored in Study II. This question was further addressed in Study III in order to understand the implications for interaction design practice. It was found that experiential bodily knowing is a form of knowing enacted through doing, and that skilful coping with and skilful appreciation of movement are core considerations for interaction design practice. My analysis in this study was conducted from the perspective of a participant observer, by combining the participants' descriptions of their experience with analysis of recorded video and data, and with my observation and experiences. The merits of this approach were discussed in Chapter 3.

Sub-question 3

> *What aspects of kinaesthetic and proprioceptive experiences could be relevant for understanding technology use and interaction design?*

The third sub-question was design oriented. It was addressed in the literature review and Studies II and III. I identified and described *tangibility*, *proximity*, *dynamics* and *body schema* as aspects of technology interactions that engage with our kinaesthetic and proprioceptive senses. I suggested that these four could be used as sensitising principles when aiming to design for fluent kinaesthetic and proprioceptive experiences. These four were further used to develop the feel dimension in Chapter 7. As such, they start to uncover potentially useful labels, concepts for thought, reflection and articulation that can be attached to kinaesthetic and proprioceptive interaction experiences and design considerations for kinaesthetic and proprioception experiences as an experiential quality. The outcomes of the third question are the main generative contribution of this thesis.

8.1.2 Contributions

In this thesis I have described how empirically-based descriptions of the experiences of moving can be transferable to, and useful for, interaction design. As with the nature of my research questions, my contributions are of theoretical, methodological and design oriented natures. See Figure 8.1 below.

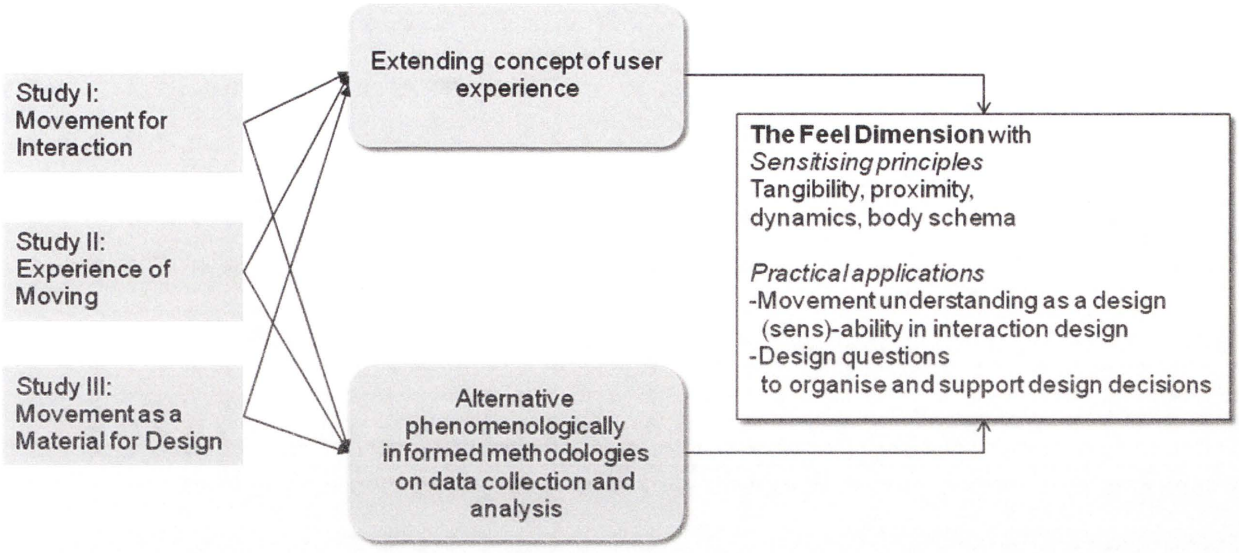


Figure 8.1: Thesis contributions

Summarised, this thesis contributes to the area of interaction design by:

- Providing three empirical studies of different aspects of movement, highlighting the use of technology enabled through movement of the body, the experience of moving and movement as a material for design;
- Providing new insights into and extending the nature of user experience by introducing kinaesthetic and proprioceptive experiences as an experiential quality;
- Presenting to HCI and interaction design, alternative phenomenologically informed methodologies on how to collect and approach data about kinaesthetic and proprioceptive experiences and the use of multiple perspectives in the analysis of this data;
- Offering the feel dimension, an articulation of the role our kinaesthetic and proprioceptive senses play in experiencing technology interactions from the point of view of people moving and acting;
- Suggesting four sensitising principles: tangibility, proximity, dynamics and body schema, as aspects that make a system good to use from the perspective of the kinaesthetic and proprioceptive senses;

- Making suggestions for movement understanding as a part of interaction design practice, that is the ability to perform, create, observe and evaluate movement, and to being able to design based in this understanding; and

- Suggesting a set of design questions following from the feel dimension, that can be used to organise and support design decisions when designing for kinaesthetic and proprioceptive experiences.

8.2 Future Work

The work presented in this thesis is a contribution in an evolving area of inquiry into our developing relationships with technology. My research addressed and answered a number of questions. However, other questions were raised as a result of the research carried out. Hence, there are a number of directions in which to extend the work in this thesis. Here I briefly outline five areas that could be pursued from this research, including:

i. further integrating the feel dimension into the concept of user experience;

ii. testing the feel dimension and its design implications in a design situation;

iii. further developing the concept of interaction design as a craft and its implication for interaction design as a practice;

iv. exploring additional relationships involved in designing movement enabled interactions; and

v. investigating how far the distinctiveness of movement could be *exploited* in interaction design.

8.2.1 Extending the Concept of User Experience

In this thesis, I suggested that the concept of user experience should be extended to also include kinaesthetic and proprioceptive experiences. This could be done by combining the understandings developed out of the feel dimension as an experiential quality with current knowledge in HCI and user experience. From HCI literature, we know that a successful interaction *gets the job done*, meaning that I effect the interaction I intended, (the interaction being clicking CTRL+P to Print or swinging my leg to kick a bad guy in an Eyetoy® game). Though as pointed out by

Djajadiningrat et al. (2000b), some interactions are not driven by ease of use, but *enjoyment of use*. This is parallel to the involvement in, and performance of, movement activities such as yoga or Parkour where the objective of the activity is being in motion rather than a movement as a function of doing. We also know that an interaction needs to *look good/right*. People are concerned with how they appear to their surroundings (e.g. elegant, dumb or awkward) while carrying out an activity with (or without) technology, and there are certain movements people are willing/unwilling to perform in a certain settings. Finally, from the feel dimension we now know that an interaction needs to *feel right* to the kinaesthetic and proprioceptive senses. This is not necessarily visible to the eye of an observer, but to the mover's internal senses telling the mover how an interaction feels. Combining these four, a nascent framework for user experience focusing on movement-enabled interaction, could consist of the following considerations: *to get an interaction done*; *enjoyment of an interaction; to look good/right* while carrying out an interaction; and for the *interaction to feel right* at the kinaesthetic and proprioceptive level. Pursuing this research agenda, could serve to further integrate the feel dimension into user experience and interaction design.

8.2.2 Testing the Feel Dimension and Design Implications

The feel dimension, as it is presented here, evolved out of empirical studies, and as it was refined, it was continually trialled conceptually. However, it has yet to be tested in a technology design situation. This is also the case for the design questions. Appropriate activities for this could include developing and testing specific ways of incorporating bodily engagement into design processes and interaction design practice, as well as exploring methodological and theoretical ways of grounding movement imagination and reflection. An undertaking such as this could lead to the testing of the design, choreographing new movements for use in interaction with technology and methods for evaluating movements used in interaction.

Apart from implementing the ideas presented here in a design process, another way of putting the ideas here to test in terms of usefulness, would be to use McCarthy and Wright's (2005) suggestion about *felt life*

> *... the test for the usefulness of this framework in any particular design or evaluation should be the extent to which it reveals or suggests aspects of HCI that may otherwise remain unconsidered* (McCarthy and Wright 2005, p. 268)

8.2.3 Interaction Design as a Craft

The framing of interaction design as a craft is not my idea. As far as I have been able to uncover, it originated in literature in 1991 with Wroblewski suggesting a number of similarities between interaction design and different types of craft. One of his arguments was that interaction design and the design of software dissolves the distinction between tools and material. In many craft activities as well as interaction design, designing involves working with the same materials from which tools are made. My thesis contributes suggestions for particular skills that designers need when working with movement as a material, for example the ability to perform, create, observe and evaluate movement. Working with movement involves working with the same material from which one part of the interaction with technology is designed.

It could be an interesting area of inquiry to further explore the implications of considering interaction design a craft on research and knowledge construction. Issues to consider include what constitutes design ability in this area; how it can be developed; what it means to perform movement practice as an interaction designer; what ways can it be studied, for example, how can accounts of both the user's and the designer's experience be captured in appropriate detail to allow reflection on design decisions; what are ways of doing design in this area; and what are the implication for the tools, materials, and methodology we use. Also, how might movement understandings be different, if at all, from the other types of skill involved in interaction design? An exploration of these issues would contribute to ongoing discussions in both design and interaction design about design-as-research and research–as-design as forms of inquiry.

8.2.4 Additional Relationships Involved in Designing Movement Enabled Interactions

Future work on this topic could also explore other relationships involved in movement-enabled interaction, apart from the mover–technology relationship. For example, there is the relationship between user and designer, and designers designing *for* movement *from* their own experiences of movement. A closer look at the implications of this from a participatory design angle would be enlightening.

A second relationship to be considered is the relationships between different *levels* of involvement in an interaction, for example spectator, participant/mover and

performers. These *levels* are not specific to movement enabled interactions, but specific considerations would be for example, a participant/mover wanting to look good/right while performing an interaction, or a spectator's experience of another person's interaction with technology. This could indicate different approaches and objectives in considering performances in interaction design.

8.2.5 *Exploiting* Distinctive Aspects of Movement

Finally, another application area for this research, could be to examine to what extent distinctive aspects of movement could be *exploited* as an intellectual property asset. Interaction modalities such as the visual (the distinct look of a product, e.g. a Macintosh computer); audio (the distinct sound of a tune, e.g. the Microsoft start-up sound or the sound of the door of a BMW closing); or smell (the smell of Crayola®, colouring chalks for children), can be and are protected using different intellectual property tools such as patents, copyright, trademark and industrial design protection measures. Similarly, some movements in interactions also have certain characteristics, e.g. shapes, which make them more easily recognisable for both a human observer and technology. (This was mentioned in Chapter 6). The question is, could distinctive aspects of movement be *exploited* by individuals or companies seeking protection for the use of movements in technology interactions? If so, what would be the focus of the protection?

Initially, an outlandish thought perhaps, these ideas were further concretized by observations made during the campaigning for the Presidential election in Ghana in 2008. The two main parties, the National Patriotic Party (NPP) and the New Democratic Congress (NDC), both designated a *signature* movement to accompany their campaign. The movements were used at rallies and also became part of people's everyday vocabulary when discussing politics. (The idea of having a signature movement actually originated with a smaller party, the Convention People's Party (CPP), but was quickly *adopted* by NPP and NDC). I witnessed a *dance off* between a NDC and NPP supporter at a party. While dancing, the two ladies involved elaborated on the NPP and NDC movements to show humorous support for their party. See still images of the movements in Figure 8.2, 8.3 and 8.4 (below). They signify change, moving forward, development and progress.

Figure 8.2: CPP - change, settle then move forward

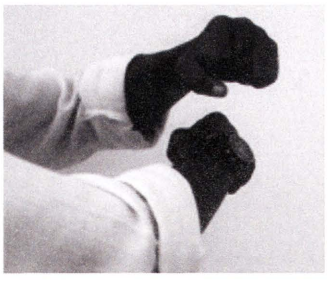


Figure 8.3: NDC - change and move forward

Figure 8.4: NPP - Kangaroo dance, moving forward

The idea is not dissimilar to the way in which the well-known extension of the arm became known as the Hitler's Heil. Both in the Ghana 2008 election campaign and during Nazi Germany, movement came to define a campaign and a political movement!

The point of this line of thought is to investigate whether a specific movement as an interaction modality could be exploited to the extent that a person or a company seeks intellectual property protection for the movement itself or for the movement as a composite of a software application. In some countries software can now be protected as either patent or as copyright (which means it is given the same protection as literary work). As far as I know, no one has sought intellectual property protection for an isolated movement. However, Nokia and Samsung have sought protection for movements used in interaction with mobile phone technology. The outcomes of these cases are pending. From my philosophical standpoint, I see it as undesirable that a company should be allowed to reserve and protect movement for their use. However, in our world less scrupulous things have happened.

8.3 In Closing

In this thesis, I have tried to understand kinaesthetic and proprioceptive experiences of technology interactions. My focus on these sense experiences is not intended to reduce human interaction with technology to the kinaesthetic and proprioceptive senses alone. In lived experience, the kinaesthetic and proprioceptive experiences would not be isolated. Our different senses make available the worlds in which we can act, but they are not reducible to each other. Each sense immerses our bodies in our worlds in different ways. My intention is to look at the specificity of the feel dimension, because it is different from the much better understood visual dimension. I

see this as an area of HCI which has received insufficient attention, but one which is becoming increasingly important due to emerging technologies.

I have concerned myself with both the phenomenon of *use* and the phenomenon of *design*. I am concerned with *use*, as in how we interact with technology, particularly as experienced through the kinaesthetic and proprioceptive senses. At the same time, I am concerned with *design*, particularly the nature of skill involved in designing *from* and *with* experiences of movement. This thesis tries to shed light on *why* these topics should be considered, *how* these topics could be approached, and by *generating articulations* of the role our kinaesthetic and proprioceptive senses play in experiencing technology interactions from the perspectives both of a person using, as well as a designer of, movement-enabled technology.

Within HCI and interaction design, I believe these ideas can be useful as conceptual tools by providing a language for thinking, talking and sensitising about kinaesthetic and proprioceptive experiences. As noted by Dourish, ethnography and ethnographically inspired work within HCI can contribute in other ways than as *implications for design* by *...the models it provides and the ways of thinking that it supports* (Dourish 2006, p. 549). In this vein, my research provides ways of engaging, exploring and inspiring empirical work in the area. My aim here has been to provide a theoretical contribution based in and developed from empirical data. Like Klooster and Overbeeke (2005) I hope that this research will engender further discussion on the role of movement in design. I believe the way forward in this important area needs to combine verbal discussions and physical explorations. This is probably also the way to evaluate theories like this one - through moving, exploring, discussing and designing.

I conducted this research in order to understand how richer understandings of kinaesthetic and proprioceptive experiences might inform as well as develop insight for interaction design. Better understanding of such experiences in interactions with technology allows us a fuller understanding of user experience by focusing *not just on how something might look*, but also on *how it might feel to use*.

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Appendix A
Guide sheet for Semi-Structured Interviews - Study II

Interview questions for movement practitioners and instructors

- Prime interviewees with questions a few days prior.
- Record: Age, gender.
- Let participants do a normal warm up to avoid injury.

Warm-up questions

- What physical activities do you participate in (all, including walking for fitness)?
- How often do you do each of these?
- How long have you been involved in these (including stopping and starting again)?
- In your opinion, how skilled or at what level do you consider yourself to be at?
- Why do you do participate in these activities?
- What keeps you going? What do you seek through doing you chosen activity? Prioritise.
- Why do you think other people participate in this/these activity/activities?

Core session - Demonstration

I would like to videotape this if OK with the participants. At about this point in the interview I would ask the participants to demonstrate a move for me as well as ask them to instruct me in how to perform it. I pick one movement and they pick one (remember to ask about props here).

- Tell me about a particular move in your practice: your favourite..., one that was the hardest to learn..., one you remember for some particular reason... (ways to access reflective information).

- Can you tell me about this movement in relation to the overall activity you do (is this a basic or advanced move, something you learn early on or later…?)
- Why do you think it is your favourite move/hard to learn/memorable…?
- Can you think of something in particular that help you learn the move?
- What do you focus on when learning the move, when doing the move?
- Can you tell me about your experience when you first started learning this move? What, if anything, is different in your current experience when performing the move?
- Any new insight into your own body/ experience of your body as a result of this move?
- When do you know you can perform this movement correctly? How do you know this?
- The "performative aspect of your activity"

- Who do you learn from, instructor only, other practitioners?
- In your opinion, how does a good instructor explain things?
- In what ways does a good instructor make a difference to you?

Props

Talk about props in relation to performance of activities.

***Cool down* questions**

- Do you experience your body differently while doing different activities?
- What words would you use to describe your engagement with the different activities you do?

Additional questions for instructors

The questions would be the same, but the instructors will also be asked about their own experience (extent of experience) as a mover, and what the relationship is to their activities as instructors.

- How do they "angle" their instructions and what do they emphasis, i.e. the way it should look, they way it should feel, where you should feel it, etc?
- How do they go about explaining moves to different people?

Interview session with both instructor and mover

Have mover perform movements they demonstrated in the first interview. Have instructor also perform this movement. Have both comment on the learning and performance of the movement.

Aims for this session

- Hear how the instructors talk about the movements compared to how the students talk about them, i.e. instructors as more skilled performers of same move.
- Understand how the instructors experience being skilled in themselves as opposed to being skilled/experienced in relation to their "student" movers.

- Have the student show and instructor correct, to hear terms used to describe and instruct.
- Observe relationship between the student and instructor. Collaborative aspect of skill building.
- Use of props – are instructors' and movers' understanding of props similar or different.