Chapter 2

Interaction Design

> We encounter the deep questions of design when we recognize that in designing tools we are designing ways of being.
>
> Winograd and Flores (1986, p.xi preface)

This chapter provides the necessary background for a thesis contributing to the field of interaction design. It covers phenomenologically-inspired and ethnographically-inspired approaches to interaction design, with a focus on embodied actions and felt experience. It introduces interaction analysis and Suchman's analytic framework. It discusses design representations and ways of seeing, including visual representations, conceptual design frameworks, personas and scenarios, and how these currently support the representation of the moving body. It concludes with a survey of methods and techniques employed by other researchers for working with the moving body in design.

2.1 Phenomenologically-inspired approaches to interaction design

> For the phenomenologist, any quest for knowledge about a phenomenon begins with the direct intuition of the phenomenon, apart from any prejudice, expectation, or reflection; hence, this direct intuition is pre-reflective. The phenomenologist's attitude toward the phenomenon is neither objective nor subjective, but rather an attitude of being present to the phenomenon, fully and wholly, to intuit it as it appears, without preshaping it in any way by prior intentions or beliefs. He is thus led to describe the 'lived experience' of the phenomenon, the essential relationship between consciousness and its world.
> (Sheets-Johnstone, 1999a, p.12)

The philosophy of phenomenology concerns itself with the phenomena of experience, of direct lived experience, and claims that these phenomena are central to questions of ontology and epistemology. Phenomenologically-inspired approaches to interaction design are characterised by the prioritising of lived experience, the valuing of experiential data and the use of first-person perspectives, accounts and methods for understanding practices and the relations to technology design and use.

There is a growing attention in the literature to felt experience and sensing, feeling and acting bodies as relevant to the design of interactive computing technologies, most recently theorised, for example, in the work of McCarthy and Wright (2005), Jacucci, Jacucci, Wagner, and Psik (2005), Klemmer, Hartmann, and Takayama (2006) and Schiphorst (2007). McCarthy and Wright (2005) call for putting 'felt-life' at the centre of human-computer interaction. The performance perspective of Jacucci et al. (2005) emphasises experiences with technology where awareness, felt-life and reflection are central to the interaction. They draw on theatrical performance practices to assist with their approach. Klemmer et al. (2006) propose five themes for interaction design: thinking through doing, performance, visibility, risk and thick practice, informed by theories of embodiment from psychology, sociology and philosophy. Schiphorst (2007) considers technology as experience

and proposes a framework from the field of somatics (the body as experienced) for understanding and accessing the body in everyday life through attentional strategies that can then be applied in design.

The recognition that all human actions (including cognition) are embodied actions, is fundamental to recent trends in interaction design. An increasing number of researchers have contributed phenomenologically-motivated theoretical perspectives on the relations between embodied actions and technology design and use (e.g., Robertson, 1996, 1997a, 2002; Dourish, 2001; Svanaes, 2001; Larssen, Robertson, and Edwards, 2005).

Robertson (1997b) established a theoretical framework that acknowledges the centrality of *experience of the actual body* to the design of systems to support people working over distance. Actual bodies imply acting and perceiving embodied subjects, in which "perception and action, are fundamentally inseparable in lived cognition" (Varela, Thompson, and Rosch, 1991, p.172–173). Her conceptualisation of actual bodies is informed by the work of Merleau-Ponty, Foucault, feminist epistemology, situated cognition and action and distributed cognition. She continues to re-articulate the phenomenology of Merleau-Ponty to the study of technology design and use. In Robertson (1996, 1997a), she applied Merleau-Ponty's notion of the *reversibility* of perception to a field study of cooperative design to develop a taxonomy of *embodied actions* that serve communicative functions in cooperative work. The taxonomy also serves as a bridging structure between the field study of cooperative work and the design of technology that might support that work over distance. In later work, Robertson (2002) again used Merleau-Ponty's notion of the reversibility of perception to stress the importance of the public availability of actions and artefacts for maintaining awareness in distributed activities.

Dourish (2001) emphasised the role of embodiment in the design of interaction when he described embodied interaction as an approach that hinges on the relationship between action and meaning as part of a larger system. Interaction design undertaken from this perspective "turns our attention away from the artefacts themselves and toward the ways in which people engage with them in different settings" (Dourish, 2001, p.184).

Svanaes (2001) promoted the application of the phenomenology of Merleau-Ponty to the design of context-aware technology, as its first-person focus on the lived body and its relation to the environment enabled understanding of such systems from the user's perspective. His analysis recognised that context must always be understood from the perspective of those whose context it is.

Larssen et al. (2005) explored multiple perspectives on movement in HCI through a comparison of biomechanics and phenomenology, laying the ground for the conceptions of movement amenable to the field of interaction design, contributed by this thesis. I elaborate this further in section 3.2, *Conceptions of movement*, as a theme running through the thesis.

Robertson (1996, 1997a) and Larssen et al. (2005) are notable for paying explicit attention to bodily actions and movement phenomena from a phenomenologically-motivated theoretical perspective. This is an area that I expand on in my thesis, by bringing together the work of two phenomenologists concerned with the centrality of movement in perception and cognition, Maxine Sheets-Johnstone and Maurice Merleau-Ponty (see section 3.1). Phenomenologically-inspired approaches to movement-based interaction motivate the research into methods and techniques for working directly with the moving body. The work of other researchers in this area is covered in section 2.5. My particular contributions to this area, one of the major foci of my thesis, are described in detail in Chapter 9.

2.2 Ethnographically-inspired approaches to interaction design

A number of researchers have applied approaches from ethnography and ethnomethodology to the study and understanding of work practices and the relations between technology design and use (e.g., Suchman, 1987, 1994a, 1995, 2007; Suchman and Trigg, 1991; Luff, Heath, and Greatbatch, 1992; Jordan, 1994; Harper and Sellen, 1995; Robertson, 1997a). These approaches involve a close scrutiny and detailed analysis of the interactional character-

istics of practitioners involved in a variety of work tasks and activities. The bodily practices and embodied actions of the practitioners often come into stronger focus in these kinds of analyses.

Research and design approaches for gesture- or movement-based technology use are emerging that are grounded in studies of work practice and everyday life (e.g., Buur et al., 2004; Brereton, Bidwell, Donovan, Campbell, and Buur, 2003; Jensen et al., 2005; Cederman-Haysom and Brereton, 2006). In particular, the research approach of Buur, Djajadiningrat and Jensen in tangible interaction design stems from an interest in building tangible user interfaces that respect and build bodily skill (Jensen et al., 2005). They conducted ethnographic fieldwork studying the work practices of brewery operators, with a focus on physical actions and bodily skill. From these studies of practice, they developed a set of design methods for capturing the characteristics and qualities of skilled physical practice, thus enabling designers to develop a feel for physical actions.

Ethnography is a research approach that implicitly and often explicitly demands that you make strange. This is because it is always interested in understanding what the 'natives' take for granted. Bell, Blythe, and Sengers (2005) work with *defamiliarising narratives*, constructed from ethnographic data on a range of cultures, to provide alternative viewpoints for helping them rethink assumptions built into domestic technologies. It is a form of *defamiliarisation* or *making strange* based on "cross-cultural juxtaposition" (Marcus and Fischer, 1986).

The shift to public or non-work settings brings different challenges to the study of human activity and interaction for use in technology design. Alternative techniques are emerging that seek partial, fragmentary data on the use—current and future—of technology in work and everyday life.

One pioneering and influential technique is *cultural probes*, devised by Gaver, Dunne, and Pacenti (1999). The cultural probes are a collection of materials such as postcards, maps, a disposable camera, a photo album and a media diary, designed to provoke inspirational responses from the community of participants. The probes collect fragmentary data over time. It is "inspirational data", intended to stimulate the imagination of the designers rather

than define a set of problems. Their approach employs the basic strategy of defamiliarisation by prompting participants to reflect on their everyday lives through the use of the probes. Gaver et al. (1999) approach research into new technologies from the tradition of artist-designers, where they concentrate on aesthetic control, the cultural implications of their designs and *ways to open new spaces for design.* The design methodology presented in this thesis operates from a similar premise of finding new ways to approach the design of movement-based interactive technologies, with an emphasis on working creatively with the experiential, moving body to generate and evaluate design proposals.

More attention is being paid to mobile and movement characteristics in studies of practice in non-traditional settings. Hagen, Robertson, Kan, and Sadler (2005) provide a review of the current state of emerging research methods for understanding mobile technology use. An important source of understanding how people move and conduct themselves in museums and galleries comes from researchers in interaction and conversation analysis (Lehn, Heath, and Hindmarsh, 2001; Heath, Luff, Lehn, Hindmarsh, and Cleverly, 2002; Hindmarsh, Heath, Lehn, and Cleverly, 2005) and museum visitor studies (Fernández and Benlloch, 2000). They have shown that people's experience and perception of an exhibit is fundamentally shaped by and through social interaction with others in the same space.

An understanding of the practices of users of technology goes hand in hand with a reflexive understanding of the practices of design. The participatory design tradition is renowned for its understanding of the design process as a process of mutual learning between professional designers and skilled users within the application domain and as a process where future or alternative technology and work organisation are envisioned and experienced rather than described (Ehn and Sjögren, 1992). Schön (1983) is influential for his insightful analysis of the practice of design. His notions of reflection-in-action and design as a reflective conversation with the materials of the situation continue to have relevance in design research and this thesis. In Chapter 6, I discuss the experiential design methods of enactment and immersion as possible categories of reflection-in-action that involve an active,

moving body and coming-to-know (Larssen et al., 2007a) through sensorial, bodily experience. The *felt* presence, positioning and motion of other people in the Bystander prototype exhibit in relation to the physical and digital properties of the interactive space were important factors for understanding and evaluating the design as part of reflection-in-action.

2.3 Interaction analysis and Suchman's analytic framework

> The starting premise is that interpreting the significance of action is an essentially collaborative achievement. Rather than depend on 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, 2007, p.86)

Suchman's (1987; 2007) pioneering work on human-machine interaction revealed the flaws in the then prevailing view of human action in cognitive science and artificial intelligence as one based on a planning model of human action. Instead she proposed an alternative view of understanding human action as *situated*. Situated action refers to "actions taken in the context of particular, concrete circumstances." (Suchman, 2007, p.26). She describes the relation between plans and situated actions:

> As commonsense constructs plans are a constituent of practical action, but they are constituent as an artifact of our *reasoning about* action, not as the generative *mechanism of* action. Our imagined projections and our retrospective reconstructions are the principal means by which we catch hold of situated action and reason about it, whereas situated action itself, in contrast, is essentially transparent to us as actors. (Suchman, 2007, p.60)

She exposes the inherent difficulties in attempting to predetermine the intention of a person's action from their observable behaviour and to then specify this in a plan to be implemented as a computer program.

Her study involved the observation and analysis of novice users attempting to use a large and relatively complex photocopier, that came with a machine called an expert help system. The purpose of the machine was to instruct the user of the photocopier in its operation. Suchman applied conversation analysis techniques from the field of ethnomethodology to the study of human-machine interaction in this instance. Suchman describes her interest in this study as,

> My central concern in the investigation is a new manifestation of an old problem in the study of mutual intelligibility; namely, the relation between observable behavior and the processes, not available to direct observation, that make behavior meaningful. [...] In either case [psychological or social studies], the problem of meaningful action turns on the observation that behavior is inherently subject to indefinitely many ascriptions of meaning or intent, while meaning or intent are expressible through an indefinite number of possible behaviors. (Suchman, 2007, p.30)

As part of the analysis, she devised an *analytic framework*, which focused on the resources available to user and machine for shared understanding in the interaction. Figure 2.1 illustrates the analytic framework. It is composed of four columns, of which the two left-hand columns describe the user actions (e.g., physical actions and talk) in terms of actions available or not to the machine and the two right-hand columns describe the machine effects and design rationale. It is organised so that the two central columns represent the mutually available, human-machine "interface". The outer columns are then the respective interpretations of the user and the design. This organisation enabled comparison and contrast of the user and machine points of view and identified the points of confusion, as well as the points of intersection or "shared understanding".

The framework was important for showing that the coherence of the user's actions was largely unavailable to the system. Only a partial trace of the user's actions was accessible to the machine. It also exposed the radical asymmetries in relative access of user and machine to contingencies of the unfolding situation. The description of the users' talk as part of their activity

The User		The Machine	
Actions not available to the machine	Actions available to the machine	Effects available to the user	Design rationale

Figure 2.1 Suchman's analytic framework

in figuring out how to use the photocopier revealed the flexible and contingent nature of human activity, in contrast to the prescribed and procedural character of the machine.

Douglas (1995) applied Suchman's analytic framework as part of her research into using conversation analysis and constructive interaction as design methods that provide contextualised information about user expectations and intentions. Episodes of user testing are videotaped for later analysis by developers. The users work in pairs following the technique of constructive interaction, where each participant "must inform the other in an explicit verbal record about problems, causes, and solutions" (Douglas, 1995, p.187). The videotapes are then analysed by developers using conversation analysis techniques and Suchman's analytic framework. Findings are then fed back into an iterative design process.

One of the key insights from Suchman's work is that assumptions about user behaviour become embedded in computer programs and influence in crucial ways the agency of potential users of interactive machines. The adaptation of Suchman's analytic framework as a design tool in this thesis enabled my focus on the conceptions designers have of users and the corresponding interpretations of user behaviour made by the machine. Used in this way, questions could be asked about the relations between user behaviour and machine behaviour and the different options available to designers. This thesis pays particular attention to conceptions of movement that form part of the design of the interactivity between users and interactive systems that utilise human movement as direct input. The specific adaptations of the framework are described in Chapter 5 (Project I, Eyetoy) and Chapter 6 (Project II, Bystander). A reflection on the use of the framework in both projects is given in Chapter 8, prior to its inclusion in the design methodology of Moving and

Making Strange, presented in Chapter 9.

2.4 Design representations and ways of seeing

> In the very broadest sense, designing is the process by which things are made. In a sense only slightly less broad, designers make representations of things to be built. They shape materials to function in some context through a web of deliberate moves and discovered consequences, often unintended. Materials resist the imposition of form and it is a rare move that has only its intended consequences. (Schön, 1990, p.110)

This section provides a certain trajectory through the literature on representations in interaction design and related fields, such as participatory design. It illustrates the roles and forms of representation in design, with a view to addressing the unique requirements of representing the moving body.

Representations are a crucial part of the design process. Each form of representation focuses on certain aspects of the design space, whilst throwing others into relief. As Bødker (1998) recognised, representations are situated within the specific practices of design and thus each design project uses and produces whatever representations are most appropriate. Her notion that design representations cross boundaries between design and use activities is fundamental to the production of representations in this research. Representations can function to promote shared understanding or as *boundary objects* (Star, 1990) which allow for multiple interpretations. The same theme of design representations offering multiple interpretations is discussed by Schön (1992) when he mentions the ambiguity of prototypes which are subject to multiple readings.

Bødker echoes Schön's (1983) notion of design as a reflective conversation with the materials of a situation, when she states that "design representations do not "stand for" existing phenomena that may be inspected alongside, but for designed phenomena, the conception of which is developing in design"

(Bødker, 1998, p.119). Schön talks of *design moves*, where the designer is engaged in a process of seeing-moving-seeing. He illustrates this concept through the example of an architect working in some visual medium, in this case, drawing:

> the designer sees what is "there" in some representation of a site, draws in relation to it, and sees what he or she has drawn, thereby informing further designing. (Schön, 1992, p.133)

Representations are intimately bound with *ways of seeing*. The works of Schön, Goodwin, Latour, Suchman and Haraway, among others, all emphasise the situated, malleable and constructed nature of seeing. Schön succinctly describes the relation between representations and ways of seeing when he states, "Stories and visual images may function like prototypes, each a source of a different way of seeing the situation." (Schön, 1990, p.134). Latour (1986) and Goodwin (1994) both speak of cultures or professions designating "what it is to see and what there is to see" (Latour, 1986, p.9). Suchman (1995, p.63) draws out the importance of one's own positioning "in relation to what we are seeing as much as any meaning inherent in the images themselves", when she analyses representations of work. The politics of positioning in relation to ways of seeing are at the heart of Haraway's arguments for situated and embodied knowledges, characterised by partial perspectives and partial connections (Haraway, 1991). Latour (1986) offers another perspective on representation and instruments of visualisation with what he terms *inscription devices*. Inscription devices work to *simplify* the messy confusion of reality and involve certain ways of seeing.

> In the debates around perception, what is always forgotten is this simple drift from watching confusing three-dimensional objects, to inspecting two-dimensional images which have been *made less confusing*. (Latour, 1986, p.15, original emphasis)

Design representations may take the form of sketches, drawings, diagrams, mock-ups, prototypes, video, scenarios, storyboards, formal notations and formal models. This is not an exhaustive nor comprehensive list; instead,

it illustrates the forms of representation commonly found in practices of interaction design and related software design disciplines, such as software engineering (Pressman, 1997; Sommerville, 2001). Anything that can stand in place of some aspect of the real thing can function as a design representation. A small subset of these representational forms, pertinent to this thesis, will be discussed in some detail, including visual representation and visual communication practices, conceptual design frameworks and scenarios.

Visual representations are graphic renderings of phenomena of interest. They organise perception and are part of visual communication practices. Conceptual design frameworks offer different ways of framing and understanding the interactions between people and interactive machines. Personas and scenarios are an established and common technique for representing users, their activities and the context of use. Each of these representational forms is discussed next and specifically, in terms of how they support the representation of different aspects of movement.

2.4.1 Visual representations and visual communication practices

The moving body is in one sense a visual medium—it can be seen by others. We can use our bodies to convey or represent ideas, qualities, forms and other meaningful aspects of the design situation. Methods for doing this are the subject of section 2.5. The moving body has a dynamic, temporal character which does not lend itself easily to static representation on paper or in digital form. Tufte (1997) points out the challenges of representing motion on paper or in static forms:

> Sequences of still images suffer the obvious (though no less important for being so) loss of the experience of the passage of time, the loss of the rates and rhythms of actual motion. (Tufte, 1997, p.109).

"the fixity of images on paper, despite clever techniques for showing motion, greatly limits representations of the quick rhythms of magic" (ibid.). Yet this same *fixity* allows designers to reason about, critique and hold onto

movement-related design concepts and understandings. In movement-based interaction design, we also need representations of movement that enable reasoning about and linking to machine input, processing and output.

In HCI, the moving body is commonly captured on video and still images are extracted from the video to represent selected postures and sequences of movement. Høysniemi and Hämäläinen (2004) experimented with various visual representations including images sequences of moving bodies extracted from video data, but abandoned Labanotation in their design of a movement-based interactive game for children. They found the image sequences easier to analyse with all the frames visible side by side. This enabled comparison and grouping of the children's movements and measurement of the frequency of steps and the different phases in the movement cycle. Buur et al. (2004) use *video action walls* to map qualities of human actions. Short video clips of physical action vignettes are clustered together and annotated with descriptive text. This technique preserves the dynamic character of movement and enables grouping of like qualities.

In Henderson's study of design engineers and their visual communication practices, visual knowledge and kinaesthetic knowledge are highlighted as two important types of nonverbal, *tacit* knowledge[1]. The use of sketches and drawings throughout the design process works to access and make explicit in some ways the tacit knowledge of various participants. The sketches and drawings "stand for or point to more complex stocks of tacit knowledge" (Henderson, 1991, p.451).

> Cognition is distributed, as it were, as various forms of nonverbal knowledge are elicited and captured to some degree through interaction with sketches and drawings. The visual representations help coordinate distributed cognition since they allow for the manipulation of tacit knowledge between individuals. (Henderson, 1991, p.450)

Henderson recasts Latour's (1986) concept of *inscription devices* as *conscription devices* in engineering design, where engineering sketches and draw-

[1] *Tacit knowing* was defined by Polanyi (1983) as a primary knowing mediated by the body prior to our ability to verbally articulate such knowing.

ings enlist and organise group participation. They serve as both a group thinking and communication tool and an individual thinking tool:

> Sketches are the real heart of visual communication. They are probably the most important carriers of visual knowledge because they serve both as an interactive communication tool and as an individual thinking tool. (Henderson, 1991, p.459)

Visual communication practices using the moving body and using representations of the moving body are still emerging and need to be developed for movement-based interaction. We need ways and language to invoke and talk about movement and qualities of movement. We also need representations that capture aspects of movement for use in reasoning about movement for input and interaction with interactive technologies and representations that facilitate re-generation of the performance and experience of movement. A growing body of researchers is addressing these very needs, as surveyed in section 2.5. This thesis focuses on representations of human movement external to the computer and representations that can serve as a bridge between human and machine perspectives. Movement notations are considered as a likely bridging representation and are discussed in section 3.3.2. Digital representations of human movement internal to the computer are covered briefly in section 3.3.3, but are outside the immediate scope of interest.

2.4.2 Conceptual design frameworks

Schön (1983) talks about framing and re-framing the design space, to generate new ways of seeing the design situation. The design process can then be considered a *frame experiment*:

> Beginning with one way of framing the problem, derived from a particular generative metaphor, we invent and implement solutions whose unanticipated effects make us aware of the selective attention or mistaken assumptions built into our initial frame. We become aware of values we did not know we held until we violated them. (Schön, 1990, p.137)

A number of conceptual design frameworks exist which offer different perspectives and ways of framing the interaction between people and interactive computing technologies. Each of these frameworks will be briefly discussed in terms of what they offer to the design of movement-based interaction.

The *Expected, Sensed and Desired* framework was developed by Benford, Schnädelbach, Koleva, Anastasi, Greenhalgh, Rodden, Green, Ghali, Pridmore, Gaver, Boucher, Walker, Pennington, Schmidt, Gellersen, and Steed (2005) to assist in the design of moveable, physical interfaces, such as mobile devices or interactive furniture. It focuses on the often complex relationship between physical form and sensing technologies. Key aspects of this framework are that *expected*, *sensed* and *desired* movements of interfaces only partially overlap and that mismatches between the categories can reveal potential problems, as well as opportunities to be exploited, in design solutions. This framework can be adapted to focus explicitly on the movements of users instead of devices. See Loke et al. (2007) for an application of the adapted framework to the analysis of movements of people interacting with Eyetoy games. In brief, 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.

Bellotti, Back, Edwards, Grinter, Henderson, and Lopes (2002) developed a framework, *Making Sense of Sensing Systems*, for the design of sensor-based systems, based on a model of human-computer interaction as human-human interaction. They focus on what happens when technology moves into the environment around us and the challenges this poses to the interaction between people and computers. Their framework is 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 in realising the interaction (Bellotti et al., 2002, p.416). The framework is composed of a set of

five issues that Bellotti et al. suggested could be posed as questions that system users must be able to answer to accomplish some action. See again Loke et al. (2007) for an application of the framework to movement-based interactions with Eyetoy. 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 in conventional GUI ways.

The *Stop Making Sense* framework by Rogers and Muller (2003) aims to inspire the design of sensor-based interactions by exploiting the unique characteristics of sensors as imprecise, unpredictable and discrete/continuous. It contains five concepts that are relevant to the design of the user experience, where reflection, exploration and discovery are valued. These concepts were transformed into a set of questions, after the style of Bellotti et al. (2002). They applied the framework to the design of a children's game, *The Hunting of the Snark*. A set of sensor-based interactions was developed to support various physical activities in the game and included sensing placement of objects, sensing location to detect virtual objects, sensing real-time gestures and sensing body movements.

Eriksson, Hansen, and Lykke-Olesen (2007) present a framework for describing and analysing camera tracking applications ranging from interactive spaces to mobile devices. It contains three concepts of *space*, *relations* and *feedback*. Despite the fact that the applications demonstrated within this framework utilise movement as input in various forms, the actual framework concepts do not employ a vocabulary for describing movement beyond basic tracking of bodies and body parts, shape, position and orientation.

Bongers and van der Veer (2007) present the *Multimodal Interaction Space* framework, for describing interaction styles starting from the physical level. It consists of three dimensions: *Levels*, *Modes* and *Modalities*. Their intention with the framework is to create interactive spaces and devices that offer rich and diverse forms of interaction, based on the three dimensions in the framework. Physical movement is an essential part of multimodal interaction, yet the framework offers little guidance for working with movement and its felt experience.

Hornecker (2005) (see also Hornecker and Buur (2006)) propose four themes in their *Tangible Interaction Framework* for the design of collaboratively used tangible interaction systems. The four themes are *tangible manipulation*, *spatial interaction*, *embodied facilitation* and *expressive representation*. They recognised that any technology offers structure that implicitly directs user behaviour by making some actions easier, whilst constraining others. In tangible interaction systems, structure is as much in the physical actions that users perform as it is in the software itself. Tangible interaction implicitly involves movements of the body, where the movement is constrained and enabled by a physical object. This in itself creates a context for movement; however, the focus of this thesis is on immersive contexts for movement that are not necessarily dependent on physical, tangible objects.

All of these frameworks treat movement in very general terms; some not at all. There is still a need for more nuanced and specific ways of describing and analysing *movement* in the interaction. Other disciplines such as dance and anthropology offer understandings, approaches, language and notation for describing and analysing movement in its richness and complexity. Some of these are covered in sections 3.2, 3.3 and 3.4. The trial, application and adoption of Laban movement analysis and description forms part of the work of this thesis and is presented in Chapters 5, 6 and 7.

2.4.3 Personas and scenarios

Well-established tools for representing users, their activities and contexts of use include personas and scenarios. Scenarios are stories or narratives in textual and/or visual form or as Bødker (2000, p.72) describes, "scenarios are selective scripts or stories that stage user actions with a future artefact." Scenarios have traditionally been used in the design of task and work-oriented technology as a means of representing users, their activities and the context of use in work situations. They have typically been used for envisioning and simulating future use situations, allowing reflection-in-action and the continuous presence of the users during the design process (Kyng, 1995; Jacobson, 1995; Bødker, 1998, 2000; Carroll, 2000a,b). More recently, scenarios

have been used for exploring situations where the setting is less well-defined and contextual information and awareness are desired such as in mobile and ubiquitous computing (Howard et al., 2002; Pedell and Vetere, 2005) and in audience experience of interactive art (Khut and Muller, 2005).

Grudin and Pruitt (2002) (see also Pruitt and Grudin (2003)) argue that most scenario-based design focuses predominantly on the context of use and actually pays little attention to the users themselves. They claim that scenarios can be much more effective when built on personas, especially when the personas are based on data collected from real people. Cooper (1999, p.124) defined personas as "hypothetical archetypes of actual users". The use of personas has been extended by others through drawing on techniques from creative writing and film (e.g., Blythe, 2004; Djajadiningrat, Gaver, and Fres, 2000; Nielsen, 2002). Djajadiningrat et al. (2000) employ the technique of *extreme characters*, fictional users with exaggerated emotional attitudes, for use in the envisionment of innovative interactive products.

Scenarios serve different purposes at different stages of the design process. Kyng (1995) describes three types of scenarios employed in cooperative design work: use, exploration and explanation scenarios. *Use* scenarios indicate how computer support and/or changes in work organisation may improve upon work situations. They describe future possibilities and "set the stage for how end users in these workshops use mockups and prototypes." (Kyng, 1995). *Exploration* (or requirement) scenarios supply the use-details and focus on whether current technical capabilities meet the requirements of the scenarios. They are more abstract in the sense that they do not contain external references to specific organisations and work situations. *Explanation* scenarios explain new possibilities for support using terms related to work situation descriptions and use scenarios. They record some of the hypothesising involved in developing specific aspects of a system or tool. In the scenario-based design approach of Rosson and Carroll (2002), scenarios serve as a central representation throughout the development cycle, first describing the goals and concerns of current use in *problem* scenarios highlighting typical and critical situations of use, then undergoing successive transformations and refinements into *activity* scenarios, *information* scenarios and *interaction*

scenarios. Bødker (2000) suggests *plus* and *minus* scenarios for evaluation of future solutions through caricatures that dramatise the positive and negative aspects respectively.

Scenarios can be used for generating performance. Scenario enactment and its various uses are covered in more detail in section 2.5.3. This research extends the tools of personas and scenarios to focus specifically on moving bodies in social contexts.

2.4.4 Summary—Design representations and ways of seeing

Design representations play a crucial role in the design process. Particularly as they imply certain ways of seeing the design situation. They function as design tools so designers can think about aspects of the design. The representation of the moving body presents new challenges to designers of movement-based interaction, where the temporal nature of the body-in-motion and the felt experience of movement are not easily transferred to traditional, static forms of representation. Video documentation attempts to alleviate the first challenge of representing the flow of movement in time, but not the second of representing the felt experience of movement.

Scenarios are promising as a means of describing and re-enacting the activity and movements of people, thus evoking patterns of movement and the felt experience of movement. One of the contributions of my thesis is the production and use of *movement-oriented* scenarios, based on *movement-oriented* personas (see Chapter 6). These two design representations of moving bodies address the lack of research in interaction design explicitly dealing with describing and representing moving bodies.

A range of conceptual design frameworks exists for exploring and evaluating the interactions of people with various kinds of interactive devices and spaces built on sensor-based technologies. The applications envisaged by the authors of the frameworks generally promote or sense physical movements and spatial interactions of users. However, the frameworks themselves treat movement in very general terms, some not at all. Designers working

in movement-based interaction need more nuanced and specific ways of describing and analysing movement in the interaction. The combined use of Suchman's analytic framework and the Laban system of movement analysis and description offers a solution to this issue and is described in Chapter 5 and Chapter 8.

2.5 Methods and techniques for working with the moving body

Researchers in human-computer interaction, interaction design and related fields have developed a variety of different approaches to designing for, and from, the moving body. Common to their approaches is a shared commitment to grounding understandings of their design domain in their own experiences as sensing, feeling and moving beings and to designing interactive systems from experiences and explorations of movement, rather than from a technological starting point.

These approaches include the use of physical movement by designers to gain a bodily understanding of gestures and movements and to communicate design ideas and findings, the use of the moving body as design material, together with developing a design sensibility for working with movement and the use of enactment and role-playing for generating, exploring and evaluating design concepts in situations of use. Inspiration for these approaches and methods has come predominantly from dance and theatrical performance practices.

2.5.1 Bodily understanding

This section describes approaches and methods for gaining bodily understanding of movement ideas and the body-in-motion and for communicating ideas and understandings with the moving body.

The notion of *experiential bodily knowing* is put forward by Larssen et al. (2007a) as "a designer's (sens)ability to reason about movement and responses to movement as part of the process of designing movement enabled

interaction with technology". In their study, this experiential bodily knowing is acquired through the learning of bodily skill in a movement practice such as pilates, yoga or Capoeira, where knowing is constructed through experiences of the body over time. This kind of knowing is *in-the-body*. They distinguish three dimensions of experiential bodily knowing: continua of knowing, the distinction between bodily knowing and understanding and the recognition of knowing in self and others. They claim that "developing greater sensibilities for recognising one's own movement experiences" (Larssen et al., 2007a) leads to an increased understanding of how others might experience movement and thus provide a more informed basis for designing.

Several researchers work with a design strategy of 'actions before product' (Buur et al., 2004; Donovan and Brereton, 2004; Jensen et al., 2005; Klooster and Overbeeke, 2005; Hummels et al., 2007). The emphasis is on understanding and exploring physical actions prior to designing "interface mechanisms that afford such actions" (Buur et al., 2004, p.186). Designers working in this way need to develop a sensitivity towards actions, physicality and qualities of movement. The *hands-only scenarios* method of Jensen et al. (2005) and Buur et al. (2004) involves the performance of a string of hand actions drawn from observations of particular work practices in order to elicit the qualities of movement in the actions and to gain a bodily understanding of the movements. One interesting finding from their work with design students in developing this method, is that re-enactment of movement without the original objects and context can become an empty gesture. In order to retain the qualities and details of the movement, they found that handling the original objects and synchronising the performance of a string of actions *amongst a group of students*, encouraged precision and retained the qualities of the movement. When working solely with movement, as is the case in my thesis, the question arises as to whether or not this is a concern. A related concern is the production of meaningful movement and the resources required to facilitate it. As the findings from my thesis suggest, the ability to generate meaningful movement is dependent to some extent on the context of action and the constraints for performance. This discussion is taken up in Chapters 5, 7 and 9.

As part of ongoing research into the design of gestural input devices for dental practitioners, Donovan and Brereton (2004) devised a gestural design game called "Meaning in movement". Participants begin with a set of three words that describe aspects of dentistry. They then choreograph a sequence of movements that reflect the words. The aim of the game is to explore and reflect upon movement qualities through the use of gesture, prior to designing specific instrument manipulations.

One method Brandt and Grunnet (2000) devised for gaining a bodily understanding of a work task (for a refrigeration technician) consists of breaking down the work task into a sequence of physical actions. The designers then perform these actions, holding each physical action like a statue or "frozen image". The acting out by designers provides a means of testing if everyone in the design team has a similar perception, from a bodily perspective, of the users and the users' work. This could be described as a shared bodily understanding.

2.5.2 The moving body as a design material and design sensibility

A small but growing number of researchers is conducting interdisciplinary work in the areas of dance (and related performance practices) and HCI (Schiphorst and Andersen, 2004; Kjölberg, 2004; Klooster and Overbeeke, 2005; Moen, 2005, 2007; Jacucci, 2006; Hummels et al., 2007; Jensen, 2007; Loke and Robertson, 2007). Dance is an artform and practice which deals exclusively with the moving body. Dance, in all its forms and traditions, offers diverse ways of understanding the body in motion and a vast range of approaches and methods for working creatively with the moving body. The focus for many of these researchers is on how to bring aspects of dance and movement practices into design practices, particularly ways of working with the moving body as a design material and design sensibility.

The approach of Schiphorst and Andersen (2004) is exemplary for attendance to bodily experience and awareness as a starting point for design. They utilise first-person methodologies from performance practices (e.g., dance,

theatre) and somatics to create gestural protocols for interaction with a wearable computing public art installation called *whisper*. In the early design phase of *whisper*, workshop participants generated movement vocabularies by negotiating permission and control of their own physiological data. The series of workshops drew on performance techniques such as improvisation, props, phantom partners, prosthetic devices, ritual space and placebo objects. One particular technique that resonates with my thesis is the focus on what they term *somatic attributes* such as breath, stillness and slow motion movement. Working with somatic attributes can heighten awareness of bodily processes and sensations and refine one's ability to articulate and control the felt experience of movement.

Researchers such as Hummels et al. (2007) advocate designers cultivating movement and kinaesthetic sensibilities and abilities to support the design of rich, expressive movement-based interaction. Larssen et al. (2007a) espouse similar commitments to developing the sensing, feeling and moving abilities of the designer or what they refer to as 'design (sens)ability'.

An example of a contemporary approach to interaction design that values aesthetic experience and more specifically, *kinaesthetic* experience is provided by Moen (2007, 2005). Moen uses people's experiences of modern dance to inform the design of a movement interaction prototype, *BodyBug*. The prototype was intended to "encourage and trigger movements and provide a possibility to sense one's (kinaesthetic) body and to move in new ways" (Moen, 2005, p.123). Moen drew on a field study of participants attending a course in improvisation and composition based on modern dance, to generate a set of movement-based design criteria corresponding to aspects of movement. For example, the movement aspect of *movement impulses* has corresponding design criteria of "create movement that trigger[s] movement; use the kinesthetic sense; no specified 'correct' or 'incorrect' use, no 'punishments' are given." (Moen, 2007, p.254). I share a similar concern with Moen (2007, p.258) for the design of future technologies, that will "influence people's movement patterns and movement habits" and thus, their ways of being in the world and the quality of their existence.

Klooster and Overbeeke (2005) introduce their *Choreography of Inter-*

action framework for the design of interactive products. The framework is based on three concepts of *Physical Involvement*, *Dynamic Quality* and *Expressed Meaning*. In their design approach, creative exploration of the movements of the user in interaction with the future product precedes the design of the physical form of the product. The final form of the product arises out of the choreography of interaction, out of the interplay between the three concepts, as the material expression of the choreography of interaction. The concept, or what they term 'pivot', of Dynamic Quality connects meaning and physicality (that is, the other two pivots of Expressed Meaning and Physical Involvement). They use three dimensions for Dynamic Quality derived from Laban's system of movement analysis—(1) Spatiality, (2) course of Time and (3) play of Forces.

The *Metaphor Lab* of Jensen (2007) consists of three design activities aimed at transferring movement qualities to the design of new interaction modalities in tangible interaction design. The first activity involves acting out movements portrayed in the *Video Action Wall* tool, to get a feel for the movement and to facilitate description of the movement qualities using Laban's Effort-Shape description. In the second activity, metaphors are created to describe the movement qualities. In the third activity, the metaphors act as the basis for designing interactive sculptures, with the aim of preserving and communicating the movement qualities through the form of physical interaction.

The masked performance techniques of Jacques Lecoq are applied by Jacucci (2006) to the field of interaction design. He reconceptualises the use of props and mock-ups in user-centred design work as 'incomplete forms' that can function as masks. Concepts for design such as neutrality, expressivity and incompleteness can be explored through performance exercises of movement based on 'neutral', 'characterised' and 'larval' masks. Jacucci (2006, p.1042) suggests masks as tools for design inquiry,

> Masks permit them [performers] to distance themselves from their own personality and even from the role of the characters they play. Ultimately, these distancing effects can articulate the inquiry by transforming the act of 'seeing' in order to make it more conscious.

Mask work enables exploration and deconstruction of movement, where the interpretation of movement is biased by the presence of the mask. Explorations with neutral masks, for example, involve experiencing movements through awakenings, journeys, encounters and farewells. These techniques complement the emerging set of methods and techniques for exploring and experiencing movement and its qualities in my proposed design methodology.

2.5.3 Enactment and physical role-playing

New methods for designing for, and from, real and imagined situations of use are emerging that view enactment and physical role-playing as key to exploring the design space. Enactment and role-playing provide ways for designers to observe users in envisioned situations of use or to directly experience the envisioned situation of use themselves. Scenario enactment extends conventional verbal 'walk-throughs' of textual vignettes by bringing the scenario to life through performance and making visible or felt, factors that are often tacit or difficult to verbalise (Carroll and Tobin, 2003). Researchers have explored techniques and devices from theatrical performance traditions to improve the process and outcomes of scenario enactment including the use of dramatisation, improvisation, role-playing and props (Ehn and Sjögren, 1992; Burns et al., 1994; Sato and Salvador, 1999; Brandt and Grunnet, 2000; Iacucci and Kuutti, 2002; Iacucci et al., 2002; Kuutti et al., 2002; Carroll and Tobin, 2003; Laurel, 2003; Mackay, 2004; Strömberg et al., 2004; Svanæs and Seland, 2004; Newell, Carmichael, Morgan, and Dickinson, 2006; Ehn, Binder, Eriksen, Jacucci, Kuutti, Linde, Michelis, Niedenthal, Petterson, Rumpfhuber, and Wagner, 2007). Some approaches advocate users acting out scenarios of future use, with designers observing and interjecting (Howard et al., 2002; Iacucci and Kuutti, 2002; Kuutti et al., 2002; Carroll and Tobin, 2003; Strömberg et al., 2004; Svanæs and Seland, 2004; Newell et al., 2006), whilst others advocate designers acting out scenarios of future use (Buchenau and Suri, 2000), with users acting as directors with expert knowledge (Brandt and Grunnet, 2000).

Ehn and Sjögren (1992) published one of the earliest examples of scenarios as scripts for action. Working within the participatory design tradition, they advocate design-by-doing and design-by-playing as engaging and meaningful ways for users to participate in the design process. Their scripts for action involve the use of games and dramatic play metaphors. Another pioneering method for acting out and physical role-playing is *bodystorming* which originated with Burns et al. (1994) and their *informance* (informative performance) design practice. They define bodystorming as the use of performance and improvisation methods for "reenacting everyday people's performances" and "living with data in embodied ways" (Burns, Dishman, Johnson, and Verplank, 1995). The key aspects of their method include designers role-playing as users, utilising simple prototypes as props and acting out performance scripts describing event sequences rather than detailed dialogue and interactions. The nature of the scripts opened up space for imagination and improvisation in character building and possible interactions with proposed design concepts. The performances also provided a common platform for discussion amongst a varied group of peers and clients.

The *Experience Prototyping* approach of Buchenau and Suri (2000) includes role-playing, improvisation and bodystorming for exploring and evaluating design ideas and prioritises designers experiencing real and imagined activities, artefacts and contexts of use *themselves*. They point out the "vividness of this owned experience [by designers] creates subjective, lasting memories which influence and guide the designers' choices and decisions" (Buchenau and Suri, 2000). They do raise, however, an interesting risk in role-playing where one can get caught up in *having* the experience, instead of *understanding* the experience. To remedy this they advocate a balance between active and passive ways of realising experience. Bodystorming has been applied by Oulasvirta et al. (2003) to the design of ubiquitous computing where they claim it enables a more accurate understanding of contextual factors such as the physical, social, interactional and psychological that are not readily observable.

Sato and Salvador (1999, p.35) present a comprehensive set of theatre techniques, under the banner of *Focus Troupes*, for "creating quick, intense,

immersive, and engaging focus group sessions" aimed at new product concept generation and evaluation. They classify which theatre techniques are most effective when actors are used to play out roles and scripts or when an audience of potential users does the acting or improvising. They also distinguish between situations when a product concept does, or does not, exist. Some examples of theatre techniques include acting out an everyday situation and providing fairy-tale props, acting out what goes on inside a product, adding objects to the situation and using the same script but changing the attitude or emotion.

Drama is explored by Brandt and Grunnet (2000) and Newell et al. (2006) as a way of staging meetings between designers and users within a participatory or user-centred design tradition. They draw on techniques from theatre to dramatise and act out scenarios, with the aim of evoking the future use of interactive products and creating empathy with users and contexts of use. Augusto Boal's Forum Theatre is a form of interventionary, political theatre where the audience is given agency over and encouraged to actively participate in the unfolding performance. Brandt and Grunnet (2000) use it with designers acting out scenarios of future use and users acting as directors with expert knowledge. Newell et al. (2006) use it to generate dialogue between designers and older, disabled users as they found traditional user-centred methods failed to adequately solicit requirements that genuinely reflected the needs of older people. Brandt and Grunnet (2000) also worked with two other techiques: Johnstone's theatre improvisation techniques and Stanislavski's acting techniques. Johnstone's theatre improvisation techniques work from the premise that improvising from well-defined restrictions assists the creative process. Brandt and Grunnet (2000) apply this principle in design work by providing guidelines for improvising use situations. Stanislavsky's "magic if" technique is used to speculate on a range of situations for character development and to build empathy with the character. Brandt and Grunnet (2000) use it to build empathy with users by speculating on what they might do in a variety of situations.

In a similar vein, Carroll and Tobin (2003) have crafted an envisionment process for future technology design aimed at simulating users immersed in

possible futures. It incorporates aspects of participatory design, Forum Theatre, Postdesign and Futures studies. Their envisionment process is chiefly concerned with the development and performance of *contextual scenarios* using endowed props where users, actors, designers and researchers can choose to participate constructively in different ways, such as observing, interjecting, envisioning or acting (Howard et al., 2002). Contextual scenarios take the form of mini-stage directions focusing on the context of use and are used to seed theatrical performances. They use actors trained in theatre improvisation as surrogate users to act out the contextual scenarios. The researchers are able to direct the scenarios on-the-fly by introducing constraints during the performance, enabling exploration of the impact of different contextual variables on the developing design ideas.

Strömberg et al. (2004) also work with Johnstone's improvisation techniques in exploring early concept definitions for ubiquitous computing. They developed the *interactive scenario* method to increase the participation of potential users in the early stages of concept design. It involves scenario role-playing and improvisation techniques for exploring physical interactions with ubiquitous computing technologies. They report that intensive work is required to prepare and reflect on an interactive scenario session. However, it is beneficial for revealing issues related to a user's spatial and physical interaction with futuristic interfaces, that may not be so readily apparent through less active and less embodied methods.

Iacucci et al. (2002) present three roles of performance, primarily in early concept design, including *exploring* design ideas, *communicating* scenarios and *testing* scenarios and concepts with mock-ups and improvisational role-playing. They identify three concepts useful for a deeper understanding of the roles of performance. The concepts include the *creation of a fictional space*, the *role of imagination* and *interactional creativity*. They present a specific method embracing these concepts called *Situated and Participative Enactment of Scenarios* (SPES) in Kuutti et al. (2002) and Iacucci and Kuutti (2002). In SPES, the designer follows a participant user in their daily activities. The user is supplied with a *magic thing*, a simple mock-up of a future device, intended to provoke ideas for new services or product

features out of new situations. The designer and user together invent and act out new scenarios of use as interesting situations arise. This method aims to generate ideas for design out of a creative, performative process. This general approach is echoed by design researchers working with movement as a design material (see section 2.5.2 above) and resonates with the principle of *making strange*, defined in my proposed design methodology (see Chapter 9).

Brenda Laurel (2003) presents *design improvisation* as a way of stimulating creativity and opening up new design spaces. Design improvisation is based on elements of theatrical improvisational techniques, theatre games and performance ethnography. In Laurel's (2003, p.54) words, "the designer uses empathy to perform design solutions that are drawn from deep identification with real, individual people in specific situated contexts in the real world."

Svanæs and Seland (2004) developed a one-day workshop format involving role-playing and lo-fi (low fidelity) prototyping for end users to contribute to the design of mobile systems. Central to their approach is putting the users centre stage and learning about potential design ideas by "observing them acting out and designing their present and future life worlds" (Svanæs and Seland, 2004, p.486).

The collaborative work of Ehn et al. (2007) has brought together many of these performance-oriented techniques to create inspirational learning environments for design and architecture students. Their advocacy of *performative interactions* in design work is resonant with my research approach, which emphasises embodied experience and attention to the interrelations between body movements, spatial interactions and system behaviour.

It should be noted that the use of scenario enactment in this thesis was primarily for design reflection on a specific system, unlike much other research which is concerned with envisionment of possible future uses of technology. Enactment and physical role-playing rely on the moving body, but the methods surveyed above do not have an explicit focus on movement *per se*.

2.5.4 Summary—Methods and techniques for working with the moving body

Performance-based techniques for enactment and role-playing offer improved means of exploring and generating design ideas and concepts, communicating design ideas between designers and users, testing and evaluating design proposals and creating empathy with users and contexts of use. Most of the approaches surveyed above in section 2.5.3 however, *do not* pay close attention to the moving body and the felt experience of movement, unlike the researchers working directly with the moving body, surveyed in the first two sections.

The felt aspects of movement and the movement itself are inseparable in the lived experience of movement. It is this twin attendance to the felt experience of movement and the visually observable aspects of movement that characterises the emerging approach to movement-based interaction design surveyed here. The researchers surveyed in section 2.5.1 recognise and promote the value of understanding and articulating these dual aspects of movement. They have developed specific methods for acquiring bodily understandings of movement and for communicating about movement through movement.

Working with the moving body as a design material inherently requires an intimate understanding of the moving body. For the researchers surveyed in section 2.5.2, the body-in-motion and its felt experience are the generative source and medium for exploration of dynamic, qualitative concepts for design and the ultimate test of successful engagement with interactive systems, products and spaces. Methods and techniques for facilitating the use of the moving body as a design material and sensibility are still emerging. The disciplines of dance, physical performance, somatics and eastern movement practices, such as Tai Chi and Chi Gong, offer abundant, not yet fully tapped, sources for these methods and techniques. Schiphorst (2007) has already done significant research in this area of drawing on first-person methodologies from somatic and performance practices and has mapped out the terrain for future research.

What is lacking in the literature, however, is a range of specific techniques and exercises for accessing and directing attention to different aspects of movement and for acquiring movement skills for working with parameters of space, time, etc. Exercises for working solo or together facilitate different kinds of knowledge and skill. In the literature, these kinds of techniques and exercises are often referred to in a blanket statement as 'physical warm-up'. It is these very techniques and exercises that designers need to practice with their own bodies in order to work productively and creatively with the moving body as a design material and design sensibility. The methods for investigating movement in my proposed design methodology are intended to serve this purpose.

2.6 Summary—Interaction Design

Phenomenologically- and ethnographically-inspired approaches to interaction design both value the lived experience of people. These approaches to design utilise methods for improving understandings of human experience, phenomena and practices prior to designing new technologies. The work of my thesis seeks to contribute to these approaches, by identifying and developing methods for accessing and understanding the lived experience of movement.

Design representations such as visual representations, conceptual design frameworks, personas and scenarios were examined for their potential to support the representation of human movement, with a view to utilising or extending existing forms of representation. We need representations that capture aspects of movement for use in reasoning about movement for input and interaction with interactive technologies and representations that facilitate re-generation of the performance and felt experience of movement. This thesis focuses on representations of human movement external to the computer and representations that can serve as a bridge between human and machine perspectives.

Suchman's analytic framework enables the analysis of the interactions between humans and machine in terms of the resources available, or not, to both user and machine. It assists with the identification of breakdowns or

misalignments in the interaction. In this thesis I explore the potential of adapting Suchman's framework as a design tool for the analysis and design of the interaction between moving bodies and movement-based interactive technologies.

Researchers working with enactment and physical role-playing in design have typically drawn on methods and techniques from theatre and improvisation practices, but their focus has not necessarily been explicitly on movement. Researchers working with the moving body as a design material and design sensibility are drawing on methods and attentional strategies from dance and somatics. The actual techniques for developing these movement-based skills are often glossed over in the published literature. My thesis seeks to contribute to these approaches, by identifying and developing methods and tools for exploring and evaluating design concepts, prototypes and systems with a specific focus on the moving body.