Embodied Engagement: Supporting Movement Awareness in Ubiquitous Computing Systems

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Abstract

This paper advocates for supporting movement awareness in ubiquitous computing as a means of transforming technology design through an approach that considers movement as an experiential component of interaction rather than a solely functional one. Somatic awareness, or the awareness of the body from the inside, is one of the primary components of movement experience, yet its resource for technology design is not yet fully understood within the field of Human-Computer Interaction (HCI). The inclusion of phenomenological movement experience in computational interaction has the potential to improve user experience, enhance the fidelity and quality of communication, and produce heightened engagement for users. Although somatic awareness has received little attention within HCI, other disciplines offer theories and frameworks that can inform the development of technology to support movement awareness. Through the discussion of theories of embodiment from a diverse range of disciplines including cognitive science, dance, somatic practices, and philosophy, this paper presents an argument for the importance of movement experience as a component of interaction with technology. It provides a history of movement within HCI, highlighting movement's role in a variety of theories and frameworks, and identifies two distinct approaches toward the utilization of movement in HCI— task oriented and experience-oriented. An in-depth discussion of experience-oriented approaches illustrates the importance of movement and somatic awareness as necessary components of ubiquitous computing systems.

Keywords: Movement, Somatics, Embodiment, Awareness, Phenomenology, Experience, Engagement, Design, Ubiquitous Computing

Introduction

Somatic awareness, or the awareness of the body from the inside, is one of the primary components of movement experience, yet it remains largely absent from approaches to interaction within HCI. While there is a growing interest in understanding the contribution of the body to computational interaction, there are still considerable insights that can be drawn from somatic awareness to the design of movement-based systems. The inclusion of a deeper understanding of phenomenological movement experience in computational interaction has the potential to transform user experience, enhance the fidelity and quality of communication, and produce heightened engagement for users, particularly in the area of ubiquitous computing.

Focusing on somatic awareness provides a unique approach to investigating and understanding the phenomenological experience of movement. A variety of techniques and methods have been developed by experts in the field of somatics to augment awareness of the lived body for therapeutic and educational purposes. These techniques can be utilized by designers in the development of new modes of interaction by emphasizing bodily experience and incorporating full body movement.

Although somatic awareness is not yet fully understood or integrated within HCI, other disciplines offer theories and frameworks that can inform the development of technology to support movement awareness. Many of these theories are grounded in philosophies of embodiment which prioritize the role of the body in the construction of human cognition and consciousness. The concept of embodiment has developed as a critical alternative to the Cartesian separation of mind and body in which the mind or brain is attributed sole responsibility for consciousness and cognition. Through the discussion of theories of embodiment from a diverse range of disciplines including cognitive science, dance, somatic practices, and philosophy, this paper illustrates the importance of movement awareness as an experiential design component of interaction with technology. It provides a history of movement within HCI, highlighting movement's role in a variety of theories and frameworks, and identifies two distinct approaches toward the utilization of movement in HCI— task oriented and experience-oriented. An in-depth discussion of experience-oriented approaches illustrates the importance of movement and somatic awareness as necessary components of ubiquitous computing systems.

Background

The concept of ubiquitous computing that originated at the Xerox Palo Alto Research Center (PARC) in the mid 1980s has shifted as technological practicalities have favored certain developments in hardware availability. In particular, mobile computing platforms such as the smart phone and tablet (e.g. iPhone, iPad, Android) have come to epitomize ubiquitous computing, overshadowing the original vision espoused by Marc Weiser and his colleagues. The smart phone model in its current instantiation satisfies the need for anytime/anywhere computing, but is limited in its ability to achieve the full expectations of ubiquitous computing which emphasize human-to-human communication and interaction, focusing on the complex social and physical environments within which computers are embedded (Weiser, Gold, & Brown, 1999).

Despite enormous advances in portability, smart phones and tablets differ little from their desktop counterparts with their reliance on text-based communication and limited support for full-body sensory engagement. The most significant advances in interaction facilitated by smart phones are made possible through the use of three technologies: capacitive sensors, accelerometers, and global positioning system (GPS) receivers. Capacitive sensing, the primary component in touch-screen technology, has alleviated the need for a keyboard and mouse and generated new forms of interaction including the use of finger gestures such as swiping and pinching as alternate forms of input. Accelerometers embedded in smart phones allow for the sensing of a device's movement in space, enabling the use of motion gestures for interaction. This use of such gestures is rarely implemented, however, as most applications only make use of an accelerometer's ability to detect tilt in order to adjust screen orientation or control visual content. The third type of technology, the GPS receiver, allows users to track their geographic location and has led to the development of a new category of applications that utilize location-

based services. These services make it easier for users to share information about the specific places that they visit and to identify and participate in social activities. While these three technologies have dramatically transformed certain aspects of computing, the interaction methods they currently facilitate act to reinforce prior models that de-emphasize bodily awareness.

Current interface designs maintain the primacy of the screen during interaction, relying on borrowed models from desktop computing that downplay the body's role in communication and experience (Pallotta, 2009). Smart phone technology has the potential to extend interaction beyond the screen, yet designers continue to develop applications that prioritize visual and aural content over other forms of sensory communication. This dependence on visual modes of input and output relies heavily on a user's attention, presenting problems for people performing common tasks such as walking or driving. The continued emphasis on visual modes of communication is due in part to the limitations of the technology, but more so because designers have not been trained to extend the scope of their thinking beyond screen-based interaction to include embodied approaches. Ubiquitous computing offers possibilities for overcoming these challenges by developing new modes of interactions that are more in line with natural human abilities and that incorporate the entire range of human sensory faculties. To achieve its potential, ubiquitous computing must move beyond a reliance on visual and auditory modes of communication and expand to include the entire body. This will require continued innovation to expand ubiquitous computing technology as well as the exploration of new embodied approaches to design thinking that better support human activity and social interactions in the world.

Embodiment

Over the last twenty years, theories of embodiment have become central to research investigations in a variety of disciplines including cognitive science, media studies, dance, performance, interactive art, and philosophy. Historically, the concept of embodiment developed as a critical alternative to the long standing Cartesian separation of the mind and body in which the mind or brain is given primacy in the construction of experience and cognition. A central tenant of all theories of embodiment is that the body is the basis for the construction of conscious experience. Theories of embodiment do not dismiss the role of the brain in cognition, but rather view it as one of the many organs that comprise the body (Rohrer, 2008).

Researchers in a variety of disciplines have identified myriad ways in which embodiment functions as an essential component in human cognitive, emotional, and social development. The following selection of research, although far from comprehensive, serves to highlight some of the major theories and areas of investigation.

George Lakoff and Mark Johnson provide an embodied account of the development of human language and conceptual thinking skills in their theory of *Embodied schemata*. Lawrence Barsalou's notion of a *perceptual symbol system* provides a complementary theory for the same phenomena (Barsalou, 1999). Antonio Damasio, a neuroscientist exploring the connection between embodiment and emotions, identified the foundational role emotions play in decision making. He also formulated the *somatic marker hypothesis* which posits, contrary to common perception, that emotions are generated within the body prior to manifesting as feelings within the brain (Damasio, 1995). Other researchers have identified connections between the body and social behavior, demonstrating, for example, the influence that various haptic qualities (e.g. hot,

cold, heavy, rough) have on inferential thinking and social judgment (Ackerman, Nocera, & Bargh, 2010; Williams & Bargh, 2008).

Research Approaches

Most embodiment research conducted within the scientific community investigates embodied cognition, a specific area of research emphasizing the role of the body in the development and support of human thought processes. This approach toward the study of embodiment is also the most often utilized within the field of Human-Computer Interaction (HCI). An alternate and less common approach to understanding embodiment is to examine the role that the body plays in the construction of lived experience. Rather than reducing the scope of investigation, the latter perspective expands it to include elements of experience that are typically considered less research worthy within the scientific paradigm. Instead of solely focusing on the body's contribution to linguistic, mathematical, or conceptual thinking, this approach emphasizes sensory and tacit knowledge directly to better understand how the body informs aspects of lived experience.

The contrast between cognitive and experiential approaches to embodiment is highlighted by scrutinizing the methods and techniques used in cognitive science and those applied in body-based practices. These methods exemplify the contrasting epistemological orientations assumed by researchers in different areas. Neuroscientists usually employ methods that involve the collection of quantitative data from fMRI machines, psychological studies, and anatomical charts (Craig, 2004; Damasio, 1995; Johnson, 2007; Rizzolatti & Craighero, 2004). One of the consequences of utilizing quantitative methods is that they tend to essentialize the body into an abstract concept, depriving it of its most prominent characteristic — movement. Researchers in the field of dance, on the other hand, generally utilize qualitative methods to study embodiment through the active use of their bodies and their first-person experience of body ownership (Laban, 1976; Sheets-Johnstone, 1999). Their methods focus on the phenomenological aspects of embodiment, highlighting the active body and its transformation through time.

Body Awareness

One discipline that is particularly well suited to the study of bodily experience is somatics. The field of somatics developed in the late 19th and early 20th century with roots in the Delsarte method as well as eastern philosophical traditions (Schiphorst, 2009). The term *somatics* was coined by Thomas Hannah in 1976 to describe the collection of disciplines exploring embodiment and sensory awareness. One of the earliest works on the subject, *The Use of the Self*, was published by F. Mathias Alexander in 1932 (Alexander, 1932). Numerous other practitioners have contributed to the canon since then, including Elsa Gindler, Moshe Feldenkrais, and Rudolph Laban (Feldenkrais, 1981; Gindler, 1995; Laban, 1976). Unlike other body-based practices, somatics does not focus on the external body, but rather is concerned with understanding the soma, the experience of the body perceived from within. This orientation provides a unique outlook that differentiates somatics from other body-based practices (Hanna, 1995).

The techniques utilized in the field of somatics function as unique and valuable research methods, providing a way to gather empirical data that are of a first-person nature. Through the cultivation of awareness, skilled somatic practitioners extend their ability to perceive the body, enhancing awareness of each limb's position and motion as well as the sensations relayed

through nerves, joints, muscles, tendons, and the skin (Hanna, 1995). This type of first-person inquiry provides an alternate approach to understanding the body and its role in structuring human experience. Additionally, it highlights the role of an active body and of movement in embodied experience.

Movement

The significant role played by movement in the construction of embodiment is most strongly articulated by Maxine Sheets-Johnstone, a researcher who approaches the study of embodiment from a phenomenologically-driven, movement-oriented perspective. Her research is informed by her work as both a dancer and a philosopher. She occupies an intellectual space between the theoretical-based approaches utilized in the field of cognitive science and the practice-based approaches used in phenomenology. She correlates findings from her phenomenological investigations with research from a variety of disciplines including evolutionary biology, neuroscience, cognitive science, and philosophy of the mind (Sheets-Johnstone, 1999). Unlike many of these researchers who focus almost exclusively on *human* cognition, Sheets-Johnstone takes an evolutionary perspective, one that views movement as a unifying concept between organisms. This perspective fosters the consideration of movement as a primary element in the construction of consciousness, one that carries across species, and that is imperative to the development of human cognition, especially during infancy and early childhood. Sheets-Johnstone is expressly interested in infancy since it is during this wordless time that our tactile-kinesthetic sense is most fundamental to human development. This idea is the basis of Sheets-Johnstone's philosophy advocating for the primacy of movement. Her claim is that an infant experiences the world corporeally, and that meaning and values are experienced kinetically through movement (Sheets-Johnstone, 1999).

Sheets-Johnstone takes a critical approach to the study of embodiment, contending that researchers often ignore the animated nature of the body. To draw attention to this distinction she discourages the use of the term *embodiment* and instead discusses *the primacy of movement* (Sheets-Johnstone, 1999). She notes that the natural attitude toward movement approaches it mathematically, as a change from one position to another. For her, movement is animation; it is the experience during the shift between positions. Sheets-Johnstone is concerned with movement that is more than merely instrumental. Movement, she contends, is used as much for utilitarian purposes as for pure enjoyment. This outlook enables a conceptualization of movement in terms of its expressive and sensory components.

A History of Movement in HCI

Movement has always been a component of computer interaction. Recent advances in tangible and ubiquitous technology, however, have transformed the way that HCI practitioners and researchers view movement. In the early history of HCI, movement was viewed primarily as a means of inputting information into a system using a mouse and a keyboard. During this period, empirical research exploring the limits of 2D interaction, such as the work done by Paul Fitts, epitomized this approach to movement (Fitts, 1954).

Recently, in the areas of Ubiquitous and Tangible Computing in particular, researchers have developed a variety of techniques that utilize movement for interaction. These methods include gestural interaction, full body kinesthetic interaction, as well as the use of specialized augmented objects and controllers. The availability of robust and easy to use camera vision systems and

accelerometers has made the use of movement for interaction not only possible, but simple and inexpensive. This has contributed to the increase in research investigating movement interaction.

Investigating the use of movement for interaction is still one of the primary approaches to the study of movement in HCI; however, over the last decade new approaches to movement have emerged that consider the role of movement in constructing the experience of interaction as well.

Movement for interaction prioritizes three particular aspects of movement: the role of movement in the development and structuring of cognition; the acquisition and use of skilled movement; and the semantic nature of movement (Table 1).

Movement as experience prioritizes two primary areas of investigation. The first, aesthetic interaction, interrogates movement through the lens of art theory, criticism and practice; the second, movement as felt experience, focuses on the first person qualitative nature of movement. Both of these approaches emphasize the qualitative nature of interaction including the emotional, expressive, and physical nature of movement (Table 2).

These two approaches, *movement for interaction* and *movement as experience*, exemplify two of the primary perspectives from which to approach designing for movement, but they are by no means mutually exclusive.

Table 1: Approaches Investigating Movement for Interaction in HCI

Cognitive Approaches	Situated Action	Activity Theory	Embodied Schemata
Skill-Based Approaches	Skills Acquisition	Characterizing Skilled Movement	Movement as Bodily-Knowledge
Semantic-Based Approaches	Meaning Through Interaction	Culturally Embedded Meaning	

Table 2: Approaches Investigating Movement as Experience in HCI

Aesthetic Interaction	Craft of Movement	Aesthetic Interaction	Tangible Aesthetics	User Experience
Movement as Felt Experience	Labanotation	Making Strange	Experience Modeling	Kinesthetic Movement Interaction

Cognitive Approaches to Movement

Cognitive approaches to movement utilize theories of embodied interaction and prioritize the interaction between organism and environment as an essential component in the development and support of cognition. Paul Dourish introduced the concept of embodied interaction to the field of HCI through his publication of the book *Where the Action Is* (Dourish, 2004). In his book, Dourish contends that computing needs to take into account the full spectrum of human skills. He introduces the concept of embodiment by tracing its origins through the history of phenomenological philosophy. Since the book's publication, numerous other researchers have explored embodied interaction, and in particular the role embodiment plays in cognition.

In HCI, three of the primary theoretical frameworks incorporating the theory of embodied cognition are *situated cognition*, *activity theory*, and the theory of *embodied schemata*. Each of these approaches emphasizes the dynamic and embedded nature of cognition.

Situated Cognition

Situated cognition stipulates that knowledge is situated in activity and bound to the specific social, cultural, and physical contexts of the environment (Lave, 1988; Nardi, 1995). Action, and thus movement, plays a central role in this theoretical framework. Cognition viewed from the lens of situated cognition is not contained within an organism or within the environment, but rather is the interrelation between the two. Situated cognition is concerned with problem solving techniques utilized within a unique situation by a specific person. It is this focus on specific actions that makes situated cognition useful to the study of movement.

Activity Theory

Activity theory, a framework developed by Alexei N. Leontiev and Sergei Rubinshtein based on the work of Soviet psychologist Lev Vygotsky, focuses on a particular *activity* as the context for cognition. The framework prioritizes the social aspects of cognition, seeing context as both internal to a person, and also externally situated in other people, objects, and settings (Nardi, 1995). Activity theory provides a framework through which to understand the dynamic connection between movement, cognition, and awareness.

Embodied Schemata

Another framework that has recently been utilized by several HCI researchers to investigate the role of movement in interaction is the theory of embodied schemata. The theory of embodied schemata posits that as humans develop, their sensory-motor interactions within the environment lead to the development of pre-linguistic constructs based on bodily movements, physical orientation, and interaction with objects (Johnson, 2007; Lakoff & Johnson, 1980). According to the theory, these schemata are utilized in conceptual metaphors to structure thought. For example, the experiential nature of humans' upright orientation in the world provides the basis for an image schema based on vertical hierarchy. This leads to *orientation* metaphors that associate UP with more and DOWN with less.

Embodied schemata were first introduced into the field of HCI by Jörn Hurtienne and Johann Israel as a framework to assist in the design of intuitive interaction for tangible user interfaces. In their paper, *Image Schemas and Their Metaphorical Extensions*, they define a system as intuitive if, "the user's unconscious application of pre-existing knowledge leads to effective interaction"

(Hurtienne & Israel, 2007). Hurtienne argues that the foundation for intuitive interaction lies in the application of conceptual metaphors in the design of systems. Alissa Antle et al. have done further research in this area, investigating the empirical basis of this claim (Antle, Corness, & Droumeva, 2009; Antle, Droumeva, & Corness, 2008).

Skill Based Approaches to Movement

Various perspectives have been utilized by researchers to explore the different facets of skilled movement. These investigations have focused on how skills are acquired, on the characteristics of skilled movement, and on movement as a form of bodily knowledge.

Skills Acquisition

In their paper *Designing the User Actions in Tangible Interaction*, Mads Vedel Jensen, Jacob Burr, and Tom Djajadiningrat describe their investigations of the use of movement in industrial settings (Jensen, Burr, & Djajadiningrat, 2005). They suggest that focusing on skilled movement-based interaction necessitates a transformation in the way products are designed. They contend that despite current trends in HCI that emphasize ease-of-use, movement-based interaction requires learning and should challenge the user. Instead of making things easy, the authors argue that designers should emphasize learning and enjoyment as the primary characteristics of interaction (Jensen, Burr, & Djajadiningrat, 2005).

Characterizing Skilled Movement

In Jensen's work he suggests using *Labanotation* as a means of transcribing movement data during ethnographic field work. Labanotation is a system of movement notation devised by Rudolph Laban for the transcription and analysis of dance choreography (Laban, 1976). Jensen focuses on Laban's breakdown of movement into the categories of *Motif*, *Effort-Shape*, and *Structural* descriptors (Jensen, Burr, & Djajadiningrat, 2005).

Tom Djajadiningrat expands on the work he did with Jensen by shifting toward characterizing movement in terms of its expressive and emotional qualities. Djajadiningrat maintains, like Jensen, that movement should be challenging, making a comparison with learning to play a musical instrument. He discusses the need to address movement flow rather than solely focusing on the functional contributions of movement to interaction (Djajadiningrat et al., 2007).

Movement as Bodily-Knowledge

Astrid Larssen, Toni Robertson, and Jenny Edwards focus on movement as a form of bodily knowledge. In their paper *Experiential Bodily Knowing as a Design (Sens)-Ability in Interaction Design,* the authors present a continuum of knowledge developed from their ethnographically-inspired field studies of Yoga, Pilates, and Capoeira practitioners (Larssen, Robertson, & Edwards, 2007). The continuum has five stages advancing from '*No Knowledge*' at one end of the spectrum to '*Knowing How to Move Completely*' at the other. They note that bodily knowledge is dynamic, and that even seasoned practitioners will shift along this continuum during practice. Larssen and her colleagues emphasize the experiential nature of bodily knowing and contend that if designers want to better utilize movement they must become experts in movement by expanding their bodily-knowledge through practice.

Robert Jacob et al. also focus on movement as a form of knowledge in their *reality-based interaction* (RBI) framework. RBI emphasizes a user's pre-existing knowledge of the real-world as an essential component of interaction. Jacob focuses particularly on four elements that are also significant to embodied interaction. These elements are: Naïve Physics, body awareness, environment awareness, and social awareness (Jacob et al., 2008). Jacob addresses the use of *whole body movement* in his discussion of body-awareness. Although not all of his other skill-sets relate directly to movement, they all address aspects of human awareness and demonstrate the role pre-existing knowledge plays in developing technology focused on the experience of movement.

Semantic Approaches

A third approach taken by researchers investigating movement interaction is the examination of the semantic properties of sensory-motor interaction. This approach focuses on the ways in which meaning is constructed through interaction between users or between the user and a computational system. Two approaches to designing for the semantic nature of movement are discussed.

Meaning Through Interaction

Sietske Klooster, Kees Overbeeke, and Caroline Hummels have worked together on several projects exploring the way that meaning is constructed through interaction and have formulated design methods for developing movement-based products. Their approach, called *design movement,* focuses on the integration of product design and dance improvisation and is based largely on work done by J.J. Gibson (Klooster & Overbeeke, 2005). From the perspective of *design movement*, movement is understood as the embodiment of interaction. This conception allows Klooster, Overbeeke, and Hummels to consider the process of designing for movement as the *choreography of interaction. Choreography of interaction* does not view the construction of meaning as occurring only between the user and the computer; rather, like previously mentioned cognitive approaches, it emphasizes the complex interplay between users, objects, and the environment (Hummels, Overbeeke, & Klooster, 2007; Klooster & Overbeeke, 2005).

Culturally Embedded Meaning

An alternate approach to investigating the semantic nature of movement interaction is to look at the role culture and history play in the construction of meaning. Asokan and Cagan argue that design decisions are often made arbitrarily and that cultural factors can make interaction more meaningful. They define culture as a shared set of beliefs and assumptions that are reflected in common practices, artifacts, and interactions (Asokan & Cagan, 2005). In their paper *Defining Cultural Identities Using Grammars: An Exploration of Cultural Languages to Create Meaningful Experiences,* they use a method called *movement grammars* to inform the design of interactive products. *Movement grammars* are developed from ethnographic field studies of specific cultures and represent the traditions, beliefs, and value system inherent to a specific group. Using *movement grammars* the researchers design interactive products that are tailored for use within a particular cultural setting.

Aesthetic Interaction

This fourth category of interaction marks the shift from thinking about *movements for interaction* to considering *movement as experience*. Researchers working with this type of movement are less concerned with the utility provided by movement and instead investigate the expressive and phenomenological characteristics of movement. This approach shares many concerns with the area of user experience; however, while researchers in user experience typically ignore bodily experience (as exemplified by McCarthy & Wright, 2004) these researchers directly address it.

The concept of aesthetic interaction is not new, and has long been of concern to designers. In his 1998 paper, *The Craft of Movement in Interaction Design*, Michael Bacigalupi investigates the role of aesthetics in constructing an interactive experience (Bacigalupi, 1998). Bacigalupi explores the integration of James Dewey's aesthetic theory with Laban's framework for movement analysis utilizing effort qualities and shape. Unlike the more recent focus in HCI on bodily movement, Bacigalupi was interested in the expressive qualities of information on a screen. His approach anticipated much of the work currently being done utilizing frameworks from dance and performance for the study of movement interaction.

Marianne Peterson, Ole Sejer, Peter Krogh, and Martin Ludvigsen explicitly use the term *aesthetic interaction* in their approach to understanding the role of movement in interaction design. Like Bacigalupi, they utilize aesthetic theories derived from pragmatist philosophers such as James Dewey and Richard Shusterman. Their approach considers the cognitive, emotional, as well as the bodily reactions of a viewer to the overall aesthetic situation (Petersen, Iversen, Krogh, & Ludvigsen, 2004). The authors suggest that taking this approach to aesthetic interaction can shift products from being purely functional to "include subtle poetic elements exciting imagination" (Petersen et al., 2004).

Although his work was covered earlier in skill-based approaches to movement, Tom Djajadiningrat's contribution to aesthetic interaction should also be noted. In his journal article *Easy Doesn't Do It: Skill and Expression in Tangible Aesthetics*, Djajadiningrat suggests that aesthetic interaction can be accomplished through the meaningful coupling of form, action, and function, and by incorporating rich user actions (Djajadiningrat, Matthews, & Stienstra, 2007). His work provides several methods for exploring aesthetic interaction, including *interaction relabeling* and *extreme personas*.

Movement as Felt Experience

The fifth approach to the study of movement interaction in HCI is through the investigations of the phenomenological aspects of the experience of movement. Many of the techniques used to explore the felt experience of movement have been utilized for other approaches; however, their use here is qualitatively different from these other approaches. For example, *Laban movement analysis* (LMA) has been used by numerous researchers as a method for conceptualizing movement. In these prior cases Laban's work is utilized in a purely theoretical and abstract manner as a framework to structure an argument. However, this is a radically different approach from using LMA as a form of bodily knowing acquired through practice. The researchers discussed in this section approach movement from this experiential perspective, incorporating movement-based practice into their investigations.

Labanotation

Lian Loke, Astrid Larssen, Toni Robertson, and Jenny Edwards – researchers working out of the University of Technology in Sydney, Australia – explicitly focus on using Labanotation as a tool for designing input into interactive systems. They completed a study of two *Sony Eye-Toy* games to explore the benefits of using Labanotation to analyze movement interaction. They relate the advantage of using Labanotation as a method of notation since it facilitates the recording of events and objects, both real and virtual. They also note some challenges of using Labanotation as a design tool, including the considerable amount of time it requires to learn the notation system, and its tendency to focus the designer's attention on the way the movement is performed by a specific individual rather than on the functional meaning of movement in general (Larssen, Robertson, Loke, & Edwards, 2007; Loke, Larssen, & Robertson, 2005).

Making Strange

Lian Loke and Toni Robertson have investigated other methods for interrogating the felt experience of movement. Of particular interest is the method they have dubbed *making strange. Making strange* is a technique for enhancing awareness of the body by disrupting habitual patterns of movement in order to draw attention to felt experience (Loke & Robertson, 2007; Sheets-Johnstone, 1999). Loke and Robertson explore the use of this method to investigate the experience of falling. For their study they recruited experienced movement practitioners and videotaped them in the act of a controlled fall. Following the enactment they conducted extensive interviews to collect first-person accounts of each participant's felt experience. They also used Labanotation as a means of representing the movements to enable comparisons between participants (Loke & Robertson, 2007).

Experience Modeling

Thecla Schiphorst, a dancer and researcher, explores the felt-experience of movement in both her artwork and research. For the development of her project *Whispers*, she and Kristina Andersen conducted participatory design workshops based around the concept of *experience-modeling*. *Experience modeling* uses existing frameworks and methods from performance, dance and somatics to construct systematic models of movement from direct experience (Schiphorst & Andersen, 2004). For their project *Whispers*, Schiphorst and Andersen were interested in devising ways to focus participants' attention on their physiological state, and to find methods for transferring physiological data between people. During design workshops they selected specific concepts and activities to aid in the identification of gestures for sharing physiological data such as *listen*, *between*, *extend*, and *mutate*. The authors suggest that *experience modeling* can provide a bridge between HCI and disciplines such as performance, dance, theater, and somatics that focus on bodily experience (Schiphorst & Andersen, 2004; Schiphorst, 2009, 2011).

Kinesthetic Movement Interaction

Jin Moen coined the term *kinesthetic movement interaction* (KMI) to describe movement based interaction that takes into account the entire human body rather than an isolated limb or set of limbs. KMI is unconstrained, requiring no hindering equipment or video screen/monitor to determine orientation. Moen utilizes modern dance as a point of departure for her work which focuses on the development of full-body, movement-based interfaces. Like many other

researchers investigating movement-based interaction, Moen conducts workshops in which she collects video data and first person qualitative accounts of movement through interviews and written exercises (Kjölberg, 2004). Moen emphasizes the need to train designers in movement and to provide them with a vocabulary with which to describe their bodily experiences (Moen, 2007). Like Schiphorst, she too utilized theories from dance and performance to ground her research. In particular, she borrows Blom and Chaplin's aspects of human movement which differentiate the various complexities of experiencing and relating movement. Moen's research produced an artifact called *The Body Bug*, an interactive wearable device that responds to its user's physical movements. The device focuses on providing enjoyment through playful and unique bodily experiences, and serves no utilitarian purpose (Moen, 2005, 2007).

Discussion

Designers of computer systems and applications have been slow to incorporate the full range of embodied experience into computational interaction. Research findings, however, demonstrate the numerous ways in which human cognition and behavior are dependent upon the experience of the body. By better understanding theories of embodiment, designers of computer systems have the opportunity to transform interaction, increasing engagement, improving the fidelity of communication, and supporting human cognition and emotional well-being. Ubiquitous computing, in particular, with its goal of facilitating human-to-human interaction within complex social and physical environments, has the potential to benefit significantly from the incorporation of the body directly into interaction. Current models of ubiquitous computing exemplified by the smart phone and tablet still rely on modes of interaction developed for desktop systems. These modes prioritize aural and visual communications which are not always suited for interaction in complex physical and social spaces with competing stimuli. They also ignore the body's communicative and expressive potential.

Although the concept of embodiment has gained considerable ground in HCI, there is still an overemphasis on theories that focus on the body's contribution to cognition alone. A chronological review of the frameworks and theories that inform the use of movement in HCI reveals an increasing awareness of the body's role in constructing experience. With mobile computing platforms transforming where, when, and how people access information, new opportunities for investigating embodied interaction are arising. In order to take advantage of these opportunities, however, a more direct approach to investigating bodily experience is necessitated. Areas traditionally considered unconnected to HCI, such as somatics and dance, are providing powerful methods for investigating embodied experience. These techniques are already being used by select researchers in HCI, and in particular by those interested in understanding the various characteristics of movement during interaction. It is with a better understanding of the role that movement experience and awareness play in the construction of embodiment that these designers will realize the full potential of ubiquitous computing

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