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HUMAN–TECHNOLOGY CHOREOGRAPHIES: BODY, MOVEMENT, AND SPACE

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Guest Editors' Introduction

HUMAN–TECHNOLOGY CHOREOGRAPHIES: BODY, MOVEMENT, AND SPACE

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CHOREOGRAPHIES: AN EMERGING PERSPECTIVE FOR INTERACTION DESIGN

In interaction design and related disciplines, the focus of research tends toward technological objects rather than the movements relating to interacting with the objects. Even when movements are considered, the emphasis is placed on their instrumental value, that is, how movements have direct effect on the functions of technology. However, the emphasis of this thematic issue *of Human Technology* rests upon the design and use of technological objects. In other words, we, as editors of this special issue, were looking for submissions that emphasized intentional human movement in the physical and social lifeworld in which humans encounter technological and virtual artifacts. The term *choreography* here refers to meaningful continuums of movement that humans, as individuals or as groups, experience during interaction with technology (see also, e.g., Loke & Reinhardt, 2012; Parviainen, Tuuri, & Pirhonen, 2013; Parviainen, Tuuri, Pirhonen, Turunen, & Keskinen, 2013).

But why do we need the concept of choreography in human technology studies? In daily life, each technological design constitutes choreographies of varying scopes: Technology may

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enable, limit, or control human movements and other behavior. Human–technology choreographies can involve anything from subtle finger movements to the movement of crowds in public spaces. A choreographic orientation, therefore, brings forth and makes explicit the opportunities and options that interaction designers have available for defining movements, movement qualities, and choreographies required when interfacing with the various devices so prevalent in contemporary living. Human movement is never a mere structure that could be handled without also affecting the inherent meanings it embodies.

When we initiated this thematic issue, we sought contributions that challenge current thinking on and critically acknowledge the role of bodily movement as a basic element in a profound understanding of relationships between humans and technology. In the call for papers, we proposed choreography as a key concept through which the movement-centered phenomena present in interaction with technology could be better acknowledged, reflected on, and understood. We hoped the submissions would represent varying orientations on the subject, for example, interaction design, product design, architecture, phenomenology, or embodied cognition, as well as more broad cultural, societal, artistic, educational, or philosophical accounts. Reports on empirical studies as well as movement-centered reinterpretations of prior research and theories were explicitly welcomed.

By the time the deadline for submissions passed, more than 20 interesting research reports were submitted for publication consideration. Not only did the quantity of submissions demonstrate that others see the value associated with our choreographic emphasis, but the range of topics validated our belief that this perspective on technology use and design could be highly influential in multiple fields.

Thus the papers submitted have resulted in a truly interdisciplinary special issue. As all who have been involved in interdisciplinary activities know, these can be rewarding as well as challenging. Different academic disciplines and related paradigms are, in Thomas Kuhn's (1980) words, incommensurable. Despite the challenges, we as researchers and special issue editors have learned that, when reconciling the traditions and approaches of different disciplines, the common ground gradually takes shape. This process of discovery and understanding is, fundamentally, what academic research is all about. In the context of human–technology choreographies, the pursuit of a common ground was challenging not only because of the typical demands of interdisciplinary work, but also because the connotations of the theme of this special issue, human–technology choreographies, proved to be extremely varied among the authors of the submissions.

Nevertheless, in spite of the variation in terms of viewpoints and approaches, the selected papers could quite effortlessly be divided into two groups: those having their focus on interaction design issues relating to choreographies within assemblages of humans and technology, and those that more specifically focus on expressivity in movement or the performative and artistic aspects within interaction design and human–technology interaction. We decided to split the submissions between two separate issues, each with a distinct perspective on human–technology choreographies but bound together through a core emphasis on the choreographic approach. The contributions in this current issue are related to the former thematic focus; a second special issue with the latter focus will be published in the coming months. In all, the articles in both issues paint a multifaceted picture of the many ways that choreographies can be utilized and acknowledged in design cases or other types of analysis.

PREVIEW OF THIS FIRST THEMATIC ISSUE

The articles in this thematic issue can be roughly organized into the following two subthemes. Papers representing the first subtheme (designing by moving) concern movement within the methodological terms of designing for and with the lived body (see Svanæs, 2013), that is, investigating meaningful and situationally appropriate physical interactions. The papers of the other subtheme (moving by design) take the inverse approach by acknowledging how technology makes users move or considers the ways designs actually choreograph movements.

Designing by Moving

Ethnography-based studies are not rare in the human–computer interaction community. However, the way in which **Parisa Eslambolchilar, Mads Bødker** and **Alan Chamberlain** approach human life is novel. They focus on an extremely everyday human action: walking. For Eslambolchilar, Bødker and Chamberlain, walking is not just mechanical usage of the body to move from one location to another. Rather, they take the reader through an intriguing journey of experiencing the world through the senses and movements of the feet. They also present a partial vocabulary to improve the understanding of the nature of and environmental issues surrounding walking and advocate that these could inform the design of mobile applications intended to be used "on the go."

Another ambitious approach to using physical activity as a source of creative ideas for design, called Bodystorming, has been studied by **Elena Márquez Segura, Laia Turmo Vidal** and **Asreen Rostami** in an article titled "*Bodystorming for Movement-based Interaction Design*." For technical reasons, their contribution was not able to be included in this current issue but will be published in an issue scheduled in the autumn.

Moving by Design

Through their account on choreographic inscriptions, **Lian Loke** and **A. Baki Kocaballi** examine qualities of movements people perform as enabled or constrained by the technology of their everyday environments. By drawing on Laban movement analysis as well as action–network theory, Loke and Kocaballi construct a theoretical framework that provides a conceptual basis for the analysis of movements in human–computer interaction. The proposed framework goes beyond the stereotypical Euclidean space by encompassing the material and the social in their analysis of movements.

The following two papers consider mobile technologies from different angles. **Jaana Parviainen** focuses on wearables and constructs a view on how micro- and macrochoreographies are generated by using wearable technologies for biomonitoring. Her conceptual tools are wide ranging, and her empirical methods include netnography and media text analysis. The paper contributes to the ongoing theoretical discussions on the "quantified self" movement and human–data interaction.

Despite their great benefits, mobile technologies may also have the negative potential to limit and discourage social interaction, as well as lock the attention of individual users onto their small screens. **Katherine Isbister, Elena Márquez Segura, Suzanne Kirkpatrick,**

Xiaofeng Chen, Syed Salahuddin, Gang Cao, and Raybit Tang challenge this by developing a mobile social game that rewards synchronized movement. They choreograph social interactions through their dance battle game, which was initially designed by adhering to two guiding design values: (a) suppleness and (b) meaningful and natural movement-based interaction. Their design took another direction through collaboration with an "indie" developer, which resulted in their incorporating a third design value (designing technology-supported play in a sociotechnical space of affordances) and led to a dramatically different but successful final design.

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WAYS OF WALKING: UNDERSTANDING WALKING'S IMPLICATIONS FOR THE DESIGN OF HANDHELD TECHNOLOGY VIA A HUMANISTIC ETHNOGRAPHIC APPROACH

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Abstract: *It seems logical to argue that mobile computing technologies are intended for use "on-the-go." However, on closer inspection, the use of mobile technologies pose a number of challenges for users who are mobile, particularly moving around on foot. In engaging with such mobile technologies and their envisaged development, we argue that interaction designers must increasingly consider a multitude of perspectives that relate to walking in order to frame design problems appropriately. In this paper, we consider a number of perspectives on walking, and we discuss how these may inspire the design of mobile technologies. Drawing on insights from non-representational theory, we develop a partial vocabulary with which to engage with qualities of pedestrian mobility, and we outline how taking more mindful approaches to walking may enrich and inform the design space of handheld technologies.*

Keywords: *walking, mobile, choreographies, non-representational theory, embodiment, design, interaction, HCI, technology, ethnography.*

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INTRODUCTION

Mobile computing technologies—by which we mean smartphones, wearable technologies, and a range of other possible devices and infrastructures intended for portability, mobile access, and use "on-the-go"—are available in all kinds of shapes, forms, and appearances, physical and tangible as well as invisible and ubiquitous. These digital artifacts and infrastructures are used in a variety of ways and contexts. In human–computer interaction (HCI), however, most of the approaches taken have been technology driven, with technological abilities defining the contextual applications, interaction, and design (Moen, 2007).

Within the rapidly growing interdisciplinary research community that participates in HCI and interaction design, we find it pertinent to elaborate on approaches for investigating the way the body moves while on foot (i.e., typically walking) that are not technology based or technology focused. This is done in order to explicate issues and understandings that arise from a stronger focus on the body, as opposed to a narrow technology focus. Many advances in HCI are concerned with what novel technologies can do as they shrink in size and gain in processing capability. These approaches are technical in their focus. Rather, we find that seeking inspiration in anthropology and ethnographic research practices enables more grounded accounts of walking. Walking, the rhythmic movement of the body in space and time, is an interaction between the walker and the land. Hence this mundane and taken-for-granted interaction can be considered a form of choreography increasingly entangled with digital information and possible interactions.

In this paper, we position walking as a ubiquitous, mundane, everyday activity that can involve a number of different experiences: from the incidental to the meditative and the arduous; from choreographed and socialized movement to accidental trips, slips, and losing one's way. Digital technologies have worked their way into day-to-day existence of human beings living in the 21st century more than ever. Technologies have become part of fluent choreographies of mundane embodiment: the everyday ways of walking.

Digital technologies offer beneficial and enjoyable experiences but can also increasingly detract from, or make people disregard, the pleasures, benefits, and human experiences of walking. We suggest that mobile technologies should be mindfully integrated into places, experiences, and situations that emerge from being on foot. We thus intend to raise awareness on the issue of walking as a sociotechnical practice and the challenges inherent in walking as an increasingly virtualized practice and experience.

We accomplish this by developing a partial vocabulary with which to engage with the qualities of pedestrian mobility. In this way, the paper is an attempt to aid and support the translation of walking as a particular form of mobility into HCI, interaction design work, and other practice-oriented engagements with technology. Additionally, walking, as an everyday choreography, offers a reflective space for a range of dynamic qualities. It offers patterns of movement that can provide a nuanced look at the use qualities of wearable devices and how the attendant interactions with these impact mobilities on foot. We suggest a move towards "choreographic thinking" (Loke, Reinhardt, & McNeilly, 2015) as a way to frame interaction design problems. Thinking choreographically, in this sense, means being mindful of patterns, compositions, and qualities of movement, the materials and spaces that structure movement on foot, as well as the software code that governs the way interactive digital and mobile/wearable devices work.

The agenda that we present in this article is framed by recent design-oriented work and research that focuses on embodiment, as well as on literature on walking as a distinctly human practice. We extend this by drawing upon our own experiences of walking in order that we might suggest particular understandings of walking as a practice. The aim is to relay this research to designers and other researchers in the HCI and interaction design communities.

For the design of mobile technologies, it seems increasingly important to ask questions such as, How do digital mobile technologies work with, as part of and in relation to, walking?, How do digital technologies and interactions shape, challenge, obstruct, or otherwise perform, choreograph, and orchestrate experiences of walking?, and, lastly, How can designers attempt to retain the benefits and pleasures of walking in an age of continuous distractions from ubiquitous, mobile, or wearable technology interactions? We argue that such challenges can best be engaged with from within the practices of walking itself.

Technologies have been implicit in the physical performance of walking for millennia. In basic terms, embodied technologies such as shoes, walking sticks, and backpacks, as well as infrastructural technologies such as paths and signs, have always shaped the ways humans walk. The transition from tree-dwelling beings to creatures who walk upright marks a significant phase in human evolution. A discussion on walking as a primordial human activity is not within the scope of the current paper. However, our fundamental assumption is that walking is, and has arguably always been, a hybrid practice that involved technology. Indeed, Rolian, Lieberman, and Hallgrimsson (2010) suggested that the very ability to build and manipulate tools with some precision with the hands may have coevolved with human bipedalism. American philosopher of technology, Don Ihde, in respect to his work on what he termed post-phenomenology (1990), discussed the inherent hybridity of humans and technology; he suggested that being human is fundamentally also being technological.

In this paper we attempt to extend well-known low-tech hybrid bodies (e.g., walker + shoes, walker + stick, walker + shoes + signs/paths) to encompass also mobile digital devices and the attendant digital infrastructures. Moreover, we introduce a number of *qualities of walking*, and we discuss how these might usefully inspire the design of mobile technologies, being mindful of the practices and qualities of everyday walking.

In the following section, we reference a number of examples from studies that have contemplated the movement of the body and experienced walking as a form of digital-hybrid mobility. We also discuss the examples that have identified specific qualities of interactive artifacts in the context of human mobility.

WALKING CONSIDERATIONS FROM THE DESIGN LITERATURE

The need to account for users' motion in HCI is increasingly recognized by interaction designers. There is not yet a shared set of dimensions or analytical frameworks for understanding how a user's bodily movement impacts the user experience, although there are conceptual forays that examine this question (e.g., Fogtmann, Fritsch, & Kortbek, 2008).

The role of walking and interaction with technology is often discussed in the context of health and physical activity (Baker et al., 2008; Consolvo, Everitt, Smith, & Landay, 2006; Harries, Rettie, Studley, Burchell, & Chambers, 2013; Lim, Shick, Harrison, & Hudson, 2011; Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006; Toscos, Faber, An, & Gandhi, 2006).

Since the birth of ubiquitous computing and, in particular the emergence of smartphones and consumer wearable devices, the ability to monitor health-related behavior has become more accessible to a wider age group of people. The use of smartphones is currently moving beyond simple step counting to include the social aspects of motivation, goal sharing, and information provision systems. However, no extensive studies have examined or discussed in much detail the qualities of walking experiences in interaction with portable or handheld devices when a person is nudged or chooses to go for a walk.

The authors referenced here have contemplated the movement of the body and experienced walking beyond a sport-based focus (Gros, 2011). We suggest this broader perspective on walking rather than a detailed domain-specific review; in other words, we do not intend to discuss examples with the distinct normative goal of enhancing particularly healthy behaviors, goals, or similar persuasive agendas.

Marshall and Tennent (2013) argued that mobile interaction designs rely largely on what they called a stop-to-interact model. Typically, an interaction with a device that is ostensibly mobile requires the user to stop moving in order to visually focus and manipulate the device. Marshall and Tennent provided a number of useful insights on the design of interactions that do not inhibit movement, including cognitive load, physical constraints, terrain, and other people. Turning towards the felt qualities of various kinds of mobility, Dix et al. (2000) discussed the nature of mobility, such as categorizing the mobility in mobile use contexts as either fixed, mobile (carried by another object), or autonomously moving around.

Isbister and Höök (2009) introduced a use quality that they termed suppleness. They understood suppleness as an interaction quality that relies on subtle social signals, emergent dynamics, and moment-to-moment experiences. As an example, they listed the iPhone as a device that supports supple experiences because of its soft and gentle gestural interaction with the touch display. However the authors did not discuss the suppleness in embodied interaction, and it was only considered in the context of design quality of interactive artifacts.

A distinct focus on movement and embodiment was pursued in Höök's (2010) work on the experience of body movements while horseback riding. Drawing on her own experiences, Höök identified themes such as the bodily ways of knowing, rhythm and balance, coinciding movement and emotion, learning the language of expressing and understanding bodily action, and describing the sensitive and delicate relationship of wordless signs and signals.

Arguing for the importance of embodied practices, Ferreira and Höök (2011) studied a tribal settlement in Vanuatu only recently introduced to mobile phones. The residents of Vanuatu's encounters with mobile use exposed the need to consider the role of the body and the role of movement when designing mobile digital technologies, as these profoundly affect a human's bodily ways of being in the world. Juhlin and Weilenmann (2013) referred to mobility in terms of the physical movements of hunters, dogs, and prey. Hunters interpret such mobilities in terms of accelerations, distance, trajectories, and temporal alignments.

Moen (2005) took modern dance as an approach to (a) provide a vocabulary for describing existing movement, as well as its quality and associated experiences that are physically based; (b) encourage personal style and individual preferences; and (c) find the essence of a movement and express the movement rather than form. Moen used five notions based on Blom and Chaplin's (1998) work to describe different aspects of human movement expressions: kinesthetic awareness, phrasing, forming, relating, and abstracting (Moen, 2007). Moen's BodyBug design took the user's attention away from the device to another form of bodily awareness, that is, awareness of the device's physical movement, although it is subtle and small (Moen & Sandsjö, 2005). In the BodyBug design, the characteristics of movement are programmable. Tholander and Johansson (2010), in their paper on skateboarders and golfers, showed that these practices do not distract users from human social interactions, even when skilled practitioners are physically interacting with their boards or golf irons. The authors made the case that an interactive technology often forces users to focus on the screen instead of interacting with others around them or with their surroundings. They identified and presented a number of design qualities for "whole body interaction" based on people's performances in these activities. This line of inquiry was followed by Pijnappel and Mueller (2013), who discussed qualities of mobility inherent in skateboarding. Their overall perspective is that it is the interdependency between the user's body, device, and physical environment that drives a rich, social, sustained, and graceful interaction with the artifacts.

On a more conceptual note, Alaoui, Caramiaux, Serrano, and Bevilacqua (2012) referred to movement quality, which they defined as "the distinctly observable attributes or characteristics produced by dynamics independently of movement trajectory or shape" (p. 2). Lim, Stolterman, Jung, and Donaldson (2007), in their work on what they termed interaction gestalt, the holistic experience and aesthetics of using interactive tools, explored how a number of different attributes of digital interaction technologies (e.g., pace, proximity, movement) give rise to an interaction gestalt, that is, the "felt shape" of an interaction with a technology.

Rather than delineating the specific qualities of interactive artifacts, we attempt to shift the focus towards some basic qualities of walking as a ubiquitous and mundane practice that increasingly provides the context for the use of mobile computing. We outline some of the difficulties of recounting walking in ways that are attentive to the seemingly subjective, felt qualities of walking. The paper retains a theoretical focus while, at the same time, exploring alternative ways of shifting theoretical abstraction towards possibilities for concrete, sensory experiences. The intention is not to merely give an account of a frame or a theoretical lens but to invite the reader into the experience of walking in a way that activates some of those sensory qualities that we treat theoretically as well as empirically in the balance of this paper.

QUALITIES OF WALKING AND NON-REPRESENTATIONAL THEORY

We propose to redirect research toward a particular ergonomics of care for bodily ways of knowing and being in the world, without putting a machine-like perspective on what the body is or could be. In other words, walking, in our rendering, is not merely an activity eligible to become enhanced or measured by machines; it is the upright body's natural movement to exist in and explore the world. What we here call qualities of walking are primarily derived from our own experiences as walkers, developed in a dialogue with concepts that originate in the field of human geography, particularly from the field known as non-representational theory.

Lorimer (2005) described non-representational theory simply as "an umbrella term for diverse work that seeks better to cope with our self-evidently more-than-human, more-than-textual, multisensual worlds" (p. 83). The often-stated aim of non-representational theory (or "more-than representational," as per Lorimer, p. 84) is to shift away from strict scholarly abstractions and the perceived necessity of positioning the researcher as a distanced observer. Instead, non-representational theory emphasizes the mobile ephemerality of sense impressions and moods, the vitality (or aliveness) and affective practices (i.e., practices affected by precognitive forces such as moods or feelings), and it acknowledges the impossibility of fully representing the living, embodied, often chaotic reality of being alive. A key tenet in non-representational theory is the aim to preserve an intimate proximity to practices and to life as it unfolds. In this sense, proximity does not mean bracketing out other things beyond those experienced closely (or losing sight of them). Instead, the aim is to preserve, in writing and in the performance and representation of research, a sense of the aliveness and sensual nature of being. Neither should it be by mimicry nor by the attempt to capture or distill a lifeworld in objective terms, but rather to experiment with animating and making sensuous the worlds rendered.

Non-representational theory and the ethnographic practices that follow from this tradition (see, e.g., Vannini, 2014) are useful for an engagement with walking practices. First and foremost, non-representational theory is "based on the leitmotif of movement in its many forms" (Thrift, 2010, p. 5). It thus shares with the sociological field of mobilities research (e.g., Büscher & Urry, 2011) an interest in the fleeting and ephemeral "on-flow" of life that traditional (or indeed representational) work cannot sufficiently grasp or indeed (re)present as text, given its insistence on an epistemology and the use of methods that freeze and stabilize the world under scrutiny. In this way, non-representational theory is particularly apt for an engagement with emerging forms of mobile life that have materialized in the wake of the massive transformations brought on by digital technologies. Non-representational theory encourages researchers to try to meet life on its own terms, and, in our case, to attempt a (re)presentation of walking in more open, creative, imaginative, and contingent forms.

The first step towards engaging with walking in a way that is espoused by and encouraged in non-representational theory is very simple. We ask the reader to engage in a slightly playful exercise to further understand some qualities of the world as one may perceive it under foot and to explore and explicate some of the sensory dimensions of walking that are challenging to transmute into a strict textual format. To let the reader participate in experiencing qualities of walking, one needs to awaken the feet as a vital way of knowing about the world. A person's feet are one of the primary points of contact with the environment; however, they are typically consigned to a lower role in the general schema of the body. The feet often take on a more unconscious and perhaps rather mechanical role compared to the hands (which are capable of fine, conscious manipulation) or the visual sense. Although people can perceive the terrain, the path, and many other qualities of walking with their eyes, their feet, as soon as they come in contact with the ground, seem to keep the brain informed about the position of the body at that exact moment, as well as the texture of the ground and the way in which its elevation changes underfoot.

So, to gently shift the reader's focus down towards the feet, before reading any further, we ask the reader (kindly) to take off her/his shoes and the socks, maybe take a short walk on whatever surface is in the room. How often do we residents of Western societies get a chance to take off our shoes and walk barefoot in public or merely work barefoot in our research labs, offices, or wherever our work takes us? While the reader is engaged in reading this article, then, we propose that the challenges and opportunities of walking with technologies might present themselves with more clarity and emphasis if the reader follows the example of two of the authors during their drafting the first version of this article (see Figure 1).

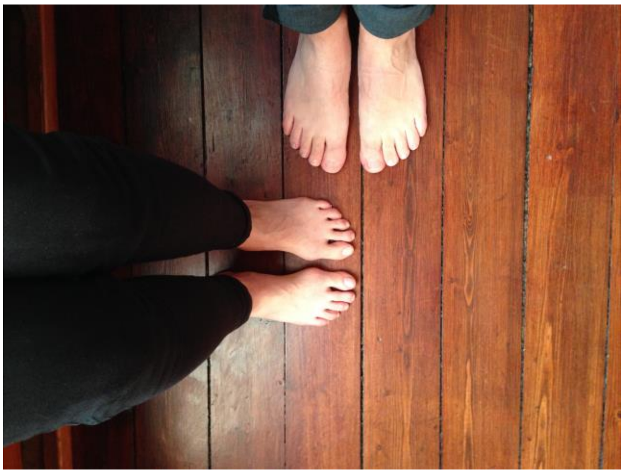

Figure 1. We are inviting the reader to experience some qualities of walking. It is as simple as taking off one's shoes and socks for a while and feeling the environment through one of the primary points of contacts, that is, the feet.

Our second step is closer to a more conventional representation. The following exposition and development of qualities take the form of short vignettes from our own walking experiences (Authors 1 and 2). We focus upon our own experiences of walking and suggest that walking can be seen as a "marginal practice" (Ljungblad & Holmqvist, 2007, p. 737) vis-à-vis the design of mobile technologies. Ljungblad and Holmqvist described marginal practices as practices wherein individuals share a specific activity that they find meaningful. Participants in such a practice have interests or needs that are particular, but their underlying motivations could be applicable also for a more general group of people. Thus, its practitioners are not regarded as end users but are involved to provide underlying human interests and qualities of interaction relevant for the design outcome.

By relating our own practices of walking, we do not suggest that we constitute a sufficient sample of relevant end users, enabling us to generalize our practices into requirements for mobile technology design. Rather, we suggest that walking, as a reflected practice, is marginal in relation to concrete design problems. Walking and reflections on the practice and experience of walking can thus work to inform design about the underlying human interests and qualities of being mobile with digital technologies and having such technologies at hand.

The fact that we, the authors of the paper, take personal walking experiences and close scrutiny of our collaborative walking practices as a starting point means that our research has duo- and autoethnographic/biographical and confessional sensibilities (Ellis, Adams, & Bochner, 2010; Sawyer & Norris, 2012; Van Maanen, 2011). The vignettes emerge from the first two authors' (Parisa and Mads) ongoing casual interest in walking, an interest that increasingly became a reflective practice as the project went along. These vignettes also constitute a dialogical reflection, developed in collaboration with the third author, on our personal and collaborative walking practices. Some of this dialogue took place as ongoing email exchanges or in the process of writing about our own personal experiences and subsequently sharing and commenting on these. Other dialogues were set in a more formal and intensive setting at a research retreat in the north of Denmark, where Parisa and Mads walked together, interspersed with periods of reflection and collaborative note writing. More dialogue followed from additional incidental walking episodes, such as walking together to work. Returning to our respective home institutions, a period of refining these notes into more coherent stories about the experience and formulating possible implications followed. Parisa's and Mads' collaborative walking and reflection at the retreat and beyond was followed up by further email exchanges between the two, the sharing of images on Flickr and other social media platforms and a number of Skype calls, as well as collaborative writing up of the experiences in documents and extended notes.

Taking a cue from duo-ethnographic approaches (Sawyer & Norris, 2012), our approach emphasized the role of dialogue in surfacing and subsequently challenging and reflecting on our individual autobiographies and experiences as walkers. Rather than examining practices and recounting them in a seemingly objective fashion, our dialogical and first-person and biographical voicing intends to express some of the richness and complexities of walking experiences from within the felt practice. When writing individually and, for instance, relating a story in spoken form, a companion author would help flesh out words and phrases that adequately described an intersubjective or shared sense of a particular walking episode. Thus our ongoing dialogues, as well as collaborative practices in the form of walking and subsequent reflections, became relevant for understanding and empathically reflecting on our own (private) embodied and mobile ways of being and knowing. While personal experiences are indeed vulnerable to criticism and are possibly highly idiosyncratic accounts that do not typically conform to the authoritative voice of scientific truths, the retelling of experiences in a dialogical space that spanned from rather informal retellings or anecdotes to intense periods of walking alone or together, writing individually as well as cowriting notes at a retreat, to follow-up conversations and further drafts (some of which were dead ends), encouraged Parisa and Mads to take turns writing short narratives that an audience could hopefully relate to, projecting themselves imaginatively into and recognizing in them a sense of the poetics of walking. Our narratives emerge in the current paper as short vignettes or episodes based on the sharing of collected notes, stories, and subsequent write-ups of our individual and collective field work. Some of these are marked as based on collaborative writing (using the plural *we*); some are more private stories retold to the other authors over the course of a few years (using *I* and indicating the author who told the story).

In these vignettes, written and refined by Parisa and Mads through a process of collaborative walking, dialogue, and reflection, we have sought to develop the poetics of walking by adopting a personal, confessional, dialogic, and expressive form. This rendering of our own experience does not aim to set walking against an overarching theoretical framework but rather to evoke some experiences or even memories of walking in the reader.

ASPECTS OF WALKING

Revisiting a selection of our own walking experiences, as well as experiences of walking together as researchers, has led us to describe six concepts that we find particularly pertinent to, and descriptive of, various aspects of walking. These are sensuality; rhythm, synchrony and balance; coincidence and narrative: hybridity; ecology of connection; and creativity. Höök argued that "certain kinds of bodily experiences are best understood through experiencing them yourself—through bodily ways of knowing" (2010, p. 3). Thus we attempt to build these concepts from short narratives or vignettes followed by a paragraph outlining the theoretical or methodological trajectories and challenges. Our intent is that these qualities can inspire designers to consider ways of walking as means of framing design problems associated with increasingly widespread mobile, embodied digital equipment.

Sensuality

Focusing first on the vitality of walking—that bodily experiences flow and dissipate in and through the body when it is walking—we emphasize that walking is far from mechanical or utilitarian but rather entails a particular way of sensing the world around. Such sensualities of walking are often more pronounced when things do not go according to plans or when mishaps and miscalculations interfere with the otherwise fluent embodiment of walking. For example, two authors of this paper decided to take a walk on the north coast of Denmark. The walk was initially planned to simply get some fresh air and sunlight and to connect with the landscape around the large coastal manor, a dedicated arts and research retreat where we had been cooped up for a couple of days.

> *We shared a walk on the North Jutland coast of Denmark few days before Christmas, and we wrapped ourselves up in thick coats, hats, gloves, and walking boots. Fearful of catching a cold (or, in one of the author's case, the cold getting even worse), we had already checked the weather conditions and the temperature using a weather app on our smartphones. Soon after embarking on our walk, we realized that we had underestimated the strong northeasterly winds! We aimed to walk a round-trip of 6.5 miles on a cold winter afternoon with only four hours of daylight. After making it halfway through the walk, we wondered whether it might a good idea to hitchhike our way back to a village nearby where we were staying for the week. We were a bit concerned about not being able to see the path, as we did not carry any torches and the daylight was fading rapidly. We did not have any water or food either. Although we were only 3 miles away from the village, we wondered whether we were going to be OK to return home safe and sound. One of the authors pointed to a public facility at an empty car park and suggested that we rest, drink some water, and decide about the best option. It was reassuring to walk with someone in the same boat as you. A few minutes later, we were both determined that we could find our way back to the village with no problems.* (Authors 1 and 2's walk, December 2014. Based on collaborative writing at a research retreat)

Vergunst (2008) argued that to understand walking as an everyday activity is not necessarily to attribute repetitiveness to the sphere of the mundane; rather, a particular sensuousness and a tactile way of knowing are central to the everydayness of walking. In the vignette above, our walk increasingly became a ramble across a mildly hostile landscape, and our senses tuned into assessing our abilities to overcome an ordeal. Although we carried both pedometers and smartphones, none of these seemed helpful or even at home in this particular setting. We felt a mounting bodily fatigue, cold winds, achy feet, and an uncertainty of what lay ahead. Also, our lack of water turned what initially began as a pleasant walk into a rather uncomfortable trek.

After participating in walks and observing hill and city walkers' behaviors, Vergunst (2008) argued that walking sensuousness allows the environment to be known through a complex, textured relationship between the walker and the ground. Yet, as much as the beauty of a landscape and other fleeting, pleasant sensations may be actualized in a walk, mishaps and miscalculations are often incorporated within the overall tale of a journey too.

Mishaps occur in all walking environments. Any number of small accidents—such as trips, slips, and losing the way—reveal aspects of the sensory relationships between the walker and her/his immediate surroundings. These mishaps are not exclusively related to rural areas; they happen in urban environments too. Uneven pavements, cobblestone surfaces, traffic, bikes, crowds of people, or ice or snow create little ruses that a walker has to endure and overcome during the walk along.

> *We were walking together to work in Copenhagen. On what seemed to be a perfectly clear and flat surface in a built environment, I accidentally fell on the pavement. It felt as if there was no reason to fall on the ground other than being a clumsy walker, yet a closer examination of the pavement proved otherwise; there was a small gap between the blocks of concrete. It had caused a little twist on my ankle and the foot could not compensate for that sudden movement, especially as I was wearing slightly high heel boots. For a few minutes we discussed what went wrong and whether it was a slip or trip. We had a shared joke on getting distracted by buildings or a new place. A few minutes later, the slip was a distant memory.* (Authors 1 and 2's walk, December 2014. Based on Author 1's notes)

Vergunst (2008) described these mishaps meticulously in his work. Tripping is an intrusion from the environment into the movement of the person. A slip, on the other hand, forces movement of the foot that is usually still. In another words, in the slip, the environment does not intrude substantially into the movement. "Trips are usually minor inconveniences, as the tripped foot is usually able simply to lift itself above the obstacle" (p.110). Vergunst described slips as more serious mishaps. They can cause loss of balance and therefore a fall. The likelihood of mishaps can engender fear in walkers in any environment: fear of slipping on ice, getting lost, being attacked in certain areas of a town, unpredictable weather, walking at night. Therefore the joy of walking is not just about enjoying the landscape; it is the experience of overcoming hardship and of learning (Vergunst, 2008).

When walking along together in precarious conditions, people often converse about the slipperiness of the path, pavement, or road. Such conversations gain their peak in the wet time of the year, which in some countries is not necessarily a seasonal event. Experienced walkers sometimes choose their footwear according to the perceived slipperiness of the path on which they are going to walk. Some walkers change their style of walking; for example, in snow the foot lift is minimized, steps are small, and legs are typically bow-shaped (Vergunst, 2008). In a group walking, there is always sympathy and support from fellow walkers when someone falls, regardless of the reason for falling, and this can benefit the person who has fallen to overcome the fear of slipping in future walks. Research has shown that older adults who experience falls in their home environment begin to lose their confidence in getting out of bed (Good & Medway, 2012). Walking with others can boost one's confidence and the body's capacity to recover. As noted by one rambler in a group walk in which one of the authors participated, "There is always someone there to give me a helping hand if I fall."

Environments are re-explored and relearned as the walker walks on regular basis; every time, the weather, sights, mood, and physical health of the walker vary. As Vergunst pointed out, "Mishaps are examples of becoming aware of what an environment is *really* like" (Vergunst, 2008, p.114).

Smartphones are capable of perceiving and communicating contextual cues, such as temperature, weather, how strong the sunlight is, and so forth. However, these digital tools are still far from inferring the shifting textures of the environment, forces, or energies exerted upon (and by) the landscape, and the tactile/sensuous and often miscalculated pragmatic ways of knowing our surroundings.

Moreover, smartphones are fragile devices and they regularly suffer mishaps in the hands or pockets of their users. They also are prone to be lost easily or left behind at the office or home. While walking, if the dropped phone is not in a protective case, it may not survive the fall. And even if it is in a case, it may not fare too well if the case is not overly durable. Many walkers in both rural and urban walks assume the front pockets of their clothing may seem like a safe place to keep the phone. But these pockets are also used for keeping keys and or loose change; so there may be an unpleasant surprise when the phone is pulled out of the pocket: scratches on the screen, dents, and spots.

The manufacturers of outdoor outfits and gear attempt to address some of these mishaps through specific designs to accommodate smartphones' safety. For example, some outdoor trousers and rucksacks have dedicated waterproof pockets for mobile phones. There are solar and biomass chargers designed for phones carried into remote and or extreme environments. These examples show that the focus of attention and care has shifted from carrying the bodies along to care also about the precious digital artifacts carried along. Ferreira and Höök (2011), from their research among the ni-Vans (i.e., inhabitants on Vanuatu), compared this caring for the device to caring for a precious and fragile living thing, like a baby.

The sensuality of caring for one's devices and their links to infrastructures challenges the sensuality of the body. As walkers, we quite often want to feel the wind, sunshine, the rain, wet snow, and cold chill on our skin. Being restricted both mentally (e.g., worrying about our digital tools, how to protect, find coverage, and charge them) and physically (e.g., issues related to our outfit) while walking has the potential to challenge some qualities of the walking experience. To get some fresh air or to clear the head, for many people, means being sensual within their bodies and letting things go. Protecting one's digital devices is an ongoing concern and the chosen outfits may limit or obstruct movement and attentional resources; in other words, a walker's experience of being in the immediate landscape can easily be disrupted by the need to maintain an awareness of her/his digital tools and the attendant infrastructures that make them valuable. A digital device with robust characteristics—similar to a solid pair of walking boots, for example, valued for the distinct patina attained over time—may reduce the overhead of caring for it.

Rhythm, Synchrony, and Balance

The French philosopher and urbanist Henri Lefebvre (2004) has written several essays on urban rhythms. His concept of rhythm concerns the repetition of a measure at a frequency. Lefebvre asserted that the human body is composed of several rhythms; in order to observe rhythms outside of the body, the so-called rhythm analyst must use her/his own rhythms as a reference to unify the rhythms under analysis. In other words, the rhythm is the conjunction of the rhythm-analyst and the object of the analysis. Vergunst extended this concept and argued, "A defining characteristic of rhythm is that it is not fixed but continually answerable to perturbations in the conditions of the task as it unfolds" (2008, p.116). This is about "carrying on," as Lee and Ingold (2006) argued, and entrainment (Gill, 2012)—the falling-into-step of other rhythms and beats. The land provides its own rhythmic structure on walking both materially (e.g., by textures, obstacles, things to avoid, and objects that attract) and semantically (e.g., by providing a landscape that we seem to read as we go along, interpreting it or stopping to respond to objects, and occurrences along the way). Figure 2 shows the landscape we encountered as a constellation of materials and textures to walk on and across, as well as objects that attracted us and called for pause and observation, thus shaping the rhythm of the walk.

Walking is rhythmic physical movement. While walking, a person never puts weight on both feet at the same time; rather, the weight shifts gently from one leg to the other, which creates a balanced gait, a cyclic rhythm. Every person has a unique rhythm of walking. If a walker is tuned into a rhythm, walking for hours can be tireless; if not, the process can be exhausting even after one hour (Gros, 2011).

> *We are back in North Jutland, walking together just before Christmas. As we begin our walk along the coast, we don't seem to have a shared rhythm. Perhaps two things intervened. Although we shared an interest in photography, we did not always have one subject of interest to photograph. Thus, looking differently at the landscape made getting into a common stride and synchronizing with one another for more than a few minutes exhausting for both of us. Another, more prosaic, artifact that intervened was footwear. The walking boots of one of us were scraping his heels, making him shift his pace and stride unpredictably. However as soon as we started chatting about something—mostly the history of the area or the landscape, such as a tall lighthouse, rocks on the beach, sea birds, etc.—our rhythm of walking became synchronized. We walked for a while with almost the same stride and the author with less comfortable walking boots almost forgot his aching heels.* (Authors 1 and 2's walk, December 2014. Based on collaborative writing at a research retreat)

Figure 2. The North Jutland coast in December: Pebbles and sand structured the route we could take and the rhythm of our walk. A lighthouse, a bright yellow cottage built close to the shore, and ruins of WWII bunkers stretched into the sea attracted our attention and led us to slow down, pause, observe, and then move along again. Each component of a landscape can impact the pace and rhythm of paired walkers.

In the ethnographic study by Vergunst (2008) during a hill walk with a group of ramblers, he related numerous irregular movements regarding going up steep hills and negotiating loose rocks and gorges. Vergunst wrote how “the rhythm of walking took its lead and its tempo from the environment of which it was part,” and that in an “uneven environment, the rhythm of the body was precisely attuned to the continuation of movement up the path” (p.117). Walking as a group creates a shared rhythm/pace of movement and the sounds and embodiment of the foot falling on the ground with people who are in close proximity (e.g., 1–2 meters). Rhythm coordinates other senses, mainly the visual, tactile, olfactory, and aural. Thus, through walking along, walkers come to inhabit (or dwell) in a space together. However the carrying on of walking can sometimes be difficult. The aching heel of one of the authors certainly restricted his movement for a while. Yet it seemed that the rhythmic walk, as well as the features of the ground and the curious objects (e.g., a lighthouse, an old cottage), required becoming attuned to the landscape, both mentally and physically.

Gill (2012) argued that the human capacity to synchronize with one another may be essential for survival as social beings. Moving in synchrony with another person involves mutual awareness or sensing. Mithen (2007) made a similar argument about singing. He imagined early humans, and even Neanderthals, needing a sense of synchrony and being as one in order to take part in collaborative hunting; a lack of synchrony was potentially fatal, either in being killed by wild prey or not being successful in hunting and starving to death. The rhythm of the body and synchrony exist between the self and the other in the mutuality of immediate social interaction (Gill, 2012). Each person has an internal rhythm (e.g., heartbeat, breathing). In becoming aware of and needing to interact with another person, the individual rhythms need to synchronize; and as the people synchronize, they can become entrained. The notion of entrainment denotes how each person mutually adapts to another’s rhythmic beat (Gill, 2012). Human sense making is thereby considered as a process of mutual adaptation that is rhythmic in quality (Gill, 2012). For example, Murray-Smith, Ramsay, Garrod, Jackson, and Musizza (2007) showed that conversation partners on mobile phones can align their walking gait without physical proximity or visual feedback. Using vibro-tactile feedback to make one conversation partner aware of another partner’s footsteps, this feedback was sufficient on its own to create synchrony. However, in the study, complex interference effects, such as breathing in the spontaneous speech condition, also helped people synchronize their pace.

Schabrun, van den Hoorn, Moorcroft, Greenland, and Hodges (2014) found that using a smartphone display, for example, typing or reading a text message while being in motion, affects the user’s gait and balance drastically. Their participants’ gait changed when using their mobile phone, with sending a text having a bigger impact than simply reading one. Schabrun et al. also found that texting caused people to slow down, swerve off course, or move their head from side to side. In summary, participants developed a distinctive posture as they strained to keep their eyes on the screen. The researchers described this posture as robot-like: “To keep their eyes steady on the phone, [the participants] ‘locked’ their arms, trunk and head together, all in aid of keeping their phone in their field of vision, so there was less movement between each of their body segments” (p. 8). This study and previous research (e.g., Menz, Lord, & Fitzpatrick, 2003) showed that an increase in the medial–lateral head motion of as small as 1.5 degrees during texting and reading, which exceeded the threshold for detecting sway with proprioceptive, visual, and vestibular systems in humans, added noise to one’s body balance information. This increased medial–lateral head motion is associated with a greater risk of falling in healthy older adults (Menz et al. 2003).

Arguably, some of the design challenges and framings that arise from an attention to rhythmic aspects of walking have to do with understanding how the rhythms of walking—for example, in walking together—can become part of the wider context that smartphones or wearables can sense and process. Smartphones or wearables with the ability to connect to each other (via, e.g., Bluetooth or other radio protocols), as well as the ability to process accelerometer and other movement data, might enable new forms of entrainment and new ways of socializing.

Coincidence and Narrative

One characteristic of the phenomenology of walking is resolving the dilemma between going forward and pulling back, that is, moving in confidence (where to go) or in fear (losing the way). Lye Tuk Po (as cited in Ingold & Vergunst, 2008, pp. 32–33) suggested that "walking takes us back to where we started from. Every arrival promises a departure but towards a point where we can come 'here' again." Lye described walking as inherently circumambulatory: Walking is about knowing how to find one's way through overlapping pathways. It includes the fear of losing one's way and of storms, freezing conditions, hunger, walking too far or too fast, blisters/injuries, and so on.

Similarly the love of a memory attached to a particular landscape can take the walker over and over to the same place as if she/he wants to relive the memory of the walk. Couples often would like to return to the landscape where they first met; every arrival in that particular spot or walking the pathway or similar pathways to the spot promises a future plan and revisits the events that have led up to that point in time.

Walking on a heritage path, a pilgrimage, or simply walking (imaginatively) in the footsteps of one's ancestors provides walkers with understanding of a world that has both continuity and change (Ingold, in Vergunst, 2008, pp. 40–44), but somehow remains in stasis. In this context, to walk is to pay close attention to the surroundings while pondering the multitude of stories related to the surroundings. Walking allows the person to gain knowledge through action and the ability to use that knowledge, for example, through narrating her/his own stories or by guiding other people. Being knowledgeable is about sharing knowledge: the culmination of listening to stories and following footprints, which also allows each walker to leave footprints for future generations to follow.

> *After we finally arrived at the North coast village where we were staying, no longer afraid of losing our way, we decided to take a stroll through the village. It was completely dark by then and there were only a few pedestrians walking the streets. Christmas decorations were visible everywhere. Gusts of cold wind blew through the cobblestoned alleys. Some shops had their lights on, showing off the stock and Christmas decorations. Close to the outskirts of the village, we came across a more modern looking two-story building. It had many tall windows, showing long corridors that had rows of doors. The garden was neat and had a few Christmas lights. Almost simultaneously, we both pointed to the building and said it looks like a care home for older people. Despite having different nationalities, despite not having lived or even visited Denmark before (in one author's case), and not being familiar with Danish design for care homes, the place held a particular feeling, a sense of being a quiet place, a sense of memories and experience, a sense of "logic" of the rural village landscape. It felt as if this sudden "local knowing" had somehow accumulated through our long walk.* (Authors 1 and 2's notes, December 2014, Based on collaborative writing at a research retreat)

The stories we weave as walkers and the ways of knowing we accumulate through movements and sensing the world are increasingly compounds of digital and physical mobilities. Most smartphones are equipped with a global positioning system (GPS) and camera. Walkers frequently use these tools to capture the moment and or the activity they are engaged in at the moment while on-the-go. We walkers can consciously decide to share these captured moments with friends or family members online, publicly or privately, through a Wi-Fi or 3G/4G/5G connection. Smartphones access the Internet via these connections through a series of towers and satellites. In making phone calls, sending texts, or connecting to the Internet, a mobile phone will "ping" or connect with any number of towers that are closest to it. This gives the phone's general location to anyone who is trying to search for it and, by extension, the location of the person using the phone. Every ping is considered to be a distinct footprint left behind, tracks on the trail. These digital footprints can be used to track not only the phone's location, but also every phone number, online account, or file shared.

An Internet protocol (IP) address is assigned to each location where the Internet can be accessed. An IP address leaves a digital footprint and that is a direct indicator that tells where a message or file originated. Every item, be it a data file, message, or audio file, will have the originating IP address attached to it in some form.

GPS is another tool widely used on mobile phones to track the device and discover its exact location. The use of GPS is widely associated with way finding. GPS can show where you are, the route you need to follow, and your final destination. The latest generation of GPS technologies is able to track walkers in urban and rural areas who have been involved in a hiking accident or lost their way and are stranded.

Digital footprints are left behind sometimes intentionally and, quite often, unintentionally. In the latter case, no matter how much we as digital users try to erase them, our digital footprints are recorded forever. With the advent of advanced hardware and slick apps, smartphones can make it far easier for digital footprints to reach further and contain more data about our physical and digital existence in the world. The benefits of this are demonstrated by a number of consumers who receive and listen to music on-the-go. For example, the Spotify app on a mobile phone can enable someone to see what her/his friends are listening to and stream or download a friend's suggestions. Mundane activities, music, and movement are brought together to give shape to mobile experiences. Such experiences, at their core, use metadata as a base to both choreograph and coalesce a range of meanings that are extrapolated from the digital world but originate from a physical interaction that involves a variety of sensory encounters.

As the development of technology has progressed, so seemingly has users' willingness to tell their stories and to increasingly share personal information with numbers of people. There are nearly 40 million Facebook users and 10 million Twitter users in the UK alone, 80% of whom access these sites via mobile devices, sharing a variety of news, their thoughts, personal feelings, reflections, and photos (Ofcom, 2014). A variety of apps or Web pages allow a user to log in through a Facebook or Twitter account. In such occasions, the user may find a displayed offer that someone else has purchased online or the location of others. This type of automation relies on the person being the linchpin in the system, meaning that, without her/his activity, the system does not work. Unintentional and intentional interaction via technology has consequences.

Sharing personal information, even when it is done intentionally, is associated with a number of risks for users of smartphones. For example, a professional and personal profile compiled from the person's digital footprint, that is, based on what he/she shares and what others say about him/her, can have a bearing on many aspects of that person's life, such as in job hunting. Many smartphone users are not interested in sharing their holiday photos with their employer but they may enjoy sharing them with work colleagues. This partial sharing or unwanted sharing may not be straightforward with existing services. One's digital footprints, unlike physical footprints, require conscious and thoughtful planning to limit unwanted exposure and may add unnecessary worry to the users rather than liberating them.

If the devices and the software running on them could not only leverage digital footprints but also enable their users to see how walking physically is collapsed into online digital traces, it might make users more aware of their intentional and unintentional digital movements. The amalgamation of the digital and the physical in this manner could reduce concerns about where and how we leave digital footprints. If digital footprints are left, we digital users could hope that they might disappear over time, like the waves wash away our footprints in the sand.

Hybridity

In the previous section, we discussed physical movement and the way this leaves digital traces or footprints when the walker carries a digital device connected to a network. Walking is a hybrid activity and, as Gros (2011) argued, "it is impossible to be alone when walking, with so many things under our gaze which are given to us through the inalienable grasp of contemplation" (p.38). He claimed everything in the landscape, from houses to fields and from forests to paths, belonged to the walker. Walking is a hybrid practice of a walker who carries things along and the ways in which these things may or may not interfere, enhance, or challenge the experience of a walk:

> *I am walking with my headphones on, and I hear the "incoming mail" ping from my smartphone. It seems to disturb the rhythmic gait of my walking. My gait becomes stiff. I need to orient myself briefly to make it possible to stop along the street to check my mail. This is perhaps a particularly "mindless" walker and technology hybrid. Through the smartphone, the urban landscape attains a virtual layer that gives rise to distracted and disconnected forms of walking. What if the mobile phone knew from embedded accelerometers that the person is walking along briskly (rather than, say, strolling) and thus notifications could be turned off? How could we create a more mindful hybridity between the walker, the landscape, and the technologies we carry along?* (Author 2 notes, November 2014)

Ingold (1993) suggested the concept of "practice-scape," arguing that land, typically represented pictorially as a "-scape" (often related to the term scope, suggesting the visual faculties thus used to master the land), could instead be defined in relation to the tasks and practices possible (and desirable) within it, thus also suggesting the etymology of the –scape suffix as a verb derived from the Old Norse word *skapa*, to create, to give shape. People thus see the land not as a three-dimensional dioramic scope but as a space for engagement and of opportunities dependent on their bodies and the equipment they bring into the land, for example, shoes, skis, an ox cart, a bicycle, a torch, a map, or a digital device. This corresponds closely with the concept of affordance in HCI, which, as defined originally by Gibson (1986), described the relationship between an organism (e.g., a human) and the action potential of the environment as a whole. Building on the notion of the practice-scape, smartphones, GPS watches, and many other wearables designed for walkers increasingly appear as new tools with which to interact with the landscape as we walk through it. How, then, are these new digital devices brought into practices? In other words, how do they perform particular choreographies of place, and how are they leveraged as artifacts of accountable (walking) practices?

Through the hybrid comprising the walker and a digital device, a sensuality (i.e., the sensed qualities) of the landscape increasingly comes to include a sense of coverage and data infrastructure. For example, when walking in a mountainous area, it will be intuitive for the experienced smartphone user to infer that 3/4/5G reception will increase on the top of a hill and decrease in the trough of a valley. The same goes for urban landscapes where buildings or being indoors has a tendency to deteriorate cell reception. In an ethnographic research project on tourism and mobile technology (Bødker & Browning, 2013), one of the authors walking along with a couple of tourists asked the participants why they wanted to go to the harbor side of a small island rather than a more well-known area of the island? The two women in their early 20s with whom he was walking answered that 3G reception was better on the harbor side of the island and that they already had gone for too long without social media use.

Concerning the artifacts of accountable practice, almost all the walkers that the authors have come across are proud of (or at least quite happy with) the marks and scratches registered on their walking sticks, rucksacks, boots/shoes, or other gear. Worn-out walking gear looks as if the walker has many tales to tell. Props like worn-out boots bolster walking narratives, and the worry of getting scratches on their equipment does not discourage the sojourner from walking. Wearing scratched and visibly worn equipment is about displaying and performing that one has used her/his kit (equipment and clothing) to walk. In other words, a walker's kit provides an account of walking. It becomes an accountable artifact: It demonstrates that the user (and wearer) of the kit is and *does* walking. In many respects, the kit provenances and evidences the activities that the walker has engaged in. It makes the ephemeral, abstract, and experiential nature of walking tangible, obvious, and accountable to others who understand walking. The kit does not interfere or challenge the experience of a walk. In regard to mobile phones, on the contrary, scratches and marks are rarely welcome. Users seem to assign a different value to their phones and, as explained in the Sensuality section, users often try to protect them dearly.

Technologies such as smartphones are not natural inhabitants in environments where the more rugged forms of movement such as rambling or hiking are the norm. Unless referring to very particular models of smartphones, the connotations of such technology rarely indicate that they are at home in the outdoors or in more rugged, adventurous settings.

The emerging practice-scapes of walking with digital technologies challenge the experience in respect to being proud of the walks we have done. The sense of accomplishment is rarely registered or displayed digitally. Although one might view and share fitness-related results and other forms of more structured data from our mobile devices, few (if any) aspects of the embodied reality of walking are registered. Unlike the scratched boot, digital records bear little resemblance to the embodied practices of walking, nor do they say anything about the qualities of a walk, the textures of the landscape, the feeling of embodied fluency, or the mishaps or obstructions encountered. While always there in the sense that movement with mobile devices creates traces and records, these are accounts that feel external to the practice through measuring distance, steps taken, elevation, and so on. To accomplish a genuine sense of hybridity, human–technology relations should create a sense of "being one"—or a centaur-like relation as described by Höök (2010) in a reference to her experiences with horseback riding—rather than being a layer abstracted from the practice.

Ecology of Connectedness

What we call the ecology of connectedness in walking is the connectedness or invisible bond between the walker; material objects such as boots, gadgets, and nature (urban, rural); and seemingly immaterial objects such as feelings, fantasies, and memories. The ecology is twofold: The ecology of connectedness is important for walking and walking is important for connectedness. For example, walking outside is to become wrapped or enfolded in an environment or world that in part consists of the weather, which gives rise to the first impression we walkers make of the world with our bare skin (face and hands) when we step out of the door. Is it cold, warm, humid, windy?

Alan Dix, a prominent HCI researcher, set for himself a challenge in the spring and the summer of 2013: to walk the circumference of Wales, UK, covering a distance about 1,000 miles (Dix, 2013, 2015). Although the walk was a personal journey, it was also a technological one, exploring the needs of the walker and other people along the way.

> *I had the pleasure of walking for a while with Alan Dix as he walked the circumference of Wales in the summer of 2013. In a full-day shared walking experience with Alan, he talked about how much his feet had hurt because he did not have the right kind of shoes to walk on the Welsh coastal path. He then discovered that sandals are the best shoes for him. Sandals, he said, are good in any weather condition for him. If he feels cold, he wears socks. If he feels hot, he takes his socks off. If it rains, the water does not fill up his boots. The technologies that connected him to the landscape were laminated maps and voice recorders (they had real physical buttons) to record his thoughts as he walked along. He found his touch-based smartphone not particularly helpful as there was poor reception and Wi-Fi connections were scarce. Moreover, on rainy and very sunny days, without shelter from the rain or shade from the sun, the display was more or less unusable. He said, "IT [information technology] deepens the division between rural and urban landscapes, but it should not."* (Author 1's notes, July 2013)

The relationship between the walker and the land is complex and multilayered, consisting of the material organization and shape of the landscape, its apparent symbolic meanings and sense of history, and the ongoing sensual perception and experience of movement. Walking not only offers distinctive forms of embodied practices, it is also a (re)production and (re)interpretation of space and place (e.g., see Edensor, 2010). Walkers can never simply pass through the land. Things in the landscape, as well as the things we walkers carry, impose themselves upon the body and our ability to walk. Despite the beauty of the walk, we must endure painful, annoying, and awkward tasks as we walk along. Walkers must avoid barbed wire, be wary when passing through fields, make sure not to step in cowpats or mud or in holes, step over logs, leap across streams, negotiate stepping stones and stiles, swat away swarms of flies, and avoid brambles, nettles, and thistles. In an urban setting, the body is constantly exposed to potholes, curbs, irregular slabs of concrete, other walkers, dog mess, wobbly cobblestones, children, lamp posts, bicycles, manhole covers, puddles, icy patches in the winter, and so on. These actions involve detailed choreographies of walking that enroll human as well as a number of nonhuman actors into a complex, finely balanced dance through the land.

The environment and the climate thus impose upon walking various strategies and sensations. The tactile qualities of many paths produce an interaction and reflection about one's balance that is necessarily mindful, as well as a practical and aesthetic awareness of textures underfoot and all around.

The connection might take on another dimension too. Hiking together, for example, walking as part of a ramblers group, is generally a very sociable experience. Vergunst (2008), in his observations of ramblers, reported that people, when walking up a steep hill, usually walk without talking because the personal effort and the amount of concentration needed to complete the task override talking. “Groups often break up at the bottom of the hill and reconvene at the top (or at the staging post), where the celebration of reaching the summit serves to bring everyone together again as they collectively gather their breath” (Vergunst, 2008, p.116).

The division between rural and urban areas, and even between many urban areas in terms of network coverage, has been discussed in the HCI literature (Chalmers, Dieberger, Höök, & Rudstrom, 2004). Regardless of the distance people walk, the lack of or poor signal reception can make people climb hills, towers, trees, and stairs; scan the room, house, building, and the space around them; and speak loudly on their phones or shout. As a result, they become disconnected from one landscape in order to connect to the invisible landscape of cellular coverage. Getting connected and remaining connected makes people explore the different layers of different landscapes: coverage, socially accepted places, private places, gestures, body movements or orientations, and so on (Ferreira & Höök, 2011). In this sense, refinding the ecology of connectedness in an age of digital communication and infrastructures might indeed entail an ongoing commitment to an invisible “Hertzian” landscape (see Dunne, 2005). Of course, being connected is not only about the signal reception: Smartphones often need to be charged at least once a day. If GPS or other navigation apps are running on the phone, the frequency of charging the phone per day increases almost exponentially (Taylor, 2015). Purpose-built navigation systems have a longer battery life than smartphones and their design is more durable. Hence, aspects of sensuality and hybridity are arguably better addressed in such devices. Being worried about running out of battery or not finding a place to charge the phone have a direct effect on a walker’s sensing and awareness; it shifts the sensuality from caring about the body to caring for a device. Looking for an electricity plug or turning certain apps or services off on the phone to save the battery temporarily disconnects the user from the landscape.

As it is, the invisible Hertzian landscapes remains incidental to the mobile phone users’ performances and particular-place choreographies. By understanding the mobile phone or wearable device, users—performing as hybrid figures and as actors in a larger ecology of connectedness, the electronic landscapes or, indeed, the Ingoldian practice-scapes of connections and infrastructures—can become a resource for designs that strive to embed digital devices gracefully into walking experiences.

Creativity

Gros (2011) argued that open-ended walks allow us walkers to lose ourselves in the experience much more than in planned walks. The open-endedness of walking and the fact that there is not really an endpoint is a quality of particular types of walking that attempt to resist a “pedometer-ideology” of walking. “Medicalizing” the landscape in order to generate a certain number of steps, miles, or kilometers from a walking experience is a very narrow vision of how digital technologies should be part of walking practices. It renders the landscape to simple numbers and measures, negating the experiential and social nature of walking. Instead, invoking a creativity of walking emphasizes qualities of playfulness and the emergent character of walking practices. Creativity and walking practices can relate to the playful or artistic appropriation of places.

> *In a number of old towns and cities in the UK, artists invite members of the public to attend ghost walks. One of the authors received an invitation to attend a 90-minute ghost walk in city of Bath. It was 8 p.m., and it was a dry and pleasant evening in August. I had looked up the starting point prior to the event but, to be on the safe side, I had printed out a small map with the meeting point highlighted. There were about 28 people on that ghost walk, of whom 16 had a paper map, 4 carried a free map from the tourist office, and the rest knew the place by heart. Everyone had had dinner before the walk. The walk was a pleasant stroll through some major landmarks at the heart of Bath. Everyone appeared to be enjoying the walk. At the final landmark, the artist who had organized the walk said, "Thank you for walking 2 miles with me. I enjoyed sharing ghostly moments with you." Many people were amazed that, in the 90 minutes, they had walked, laughed, felt the fear, talked, and made new friends.* (Author 1's notes, August 2014)

Many major cities have an underground service and in some countries employees may go on strike. This is not welcome news to commuters and tourists. However, to alleviate the stress of such situations, some city officials have produced a creative walk design, a walking map for users of underground services, such as the "London Walking Tube Map" (West, 2014). Such maps show the walking distance (in minutes) between each stop along the street. Moreover, it lists the city's landmark sites that would be missed if one traveled underground.

One might similarly look to algorithmic walking as a way of doing "disruptive" engagements, particularly in an urban context. By applying the model of an algorithm to a walk, psycho-geographers (e.g., Pinder, 2005) have attempted to challenge the predictable, orderly, and indeed ordering structures of urban landscapes by applying generative methods to shape a walk. For instance, by scripting the walker to go for "one block, then one block left, then two blocks right, then repeat," any habitual and materially structured walking, devoid of adventure and discovery, is contested. This is an active resistance to the pedometer ideology. Pedometers are certainly designed specifically for bipedalism but, as we have discussed, can be seen as devices that inhibit qualities of creativeness and openness in walking by providing binary (e.g., either you did or did not reach your goal) or exclusively quantitative representations of walking activities (e.g., simply stating the number of steps or length of walk).

The creative design space for pedometer devices (or the output of pedometers) is underexplored. People might, on their own accord, be creative in an effort to maximize the number or steps recorded in a day (e.g., Consolvo et al., 2006; Harries et al., 2013; Lim et al., 2011; Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006), leading them to explore the ability of the pedometer to create new experiences and other qualities of walking. We argue that, even in the health and behavior-change literature subscribing to behavioral and economic versions of motivations and change, psycho-geographical sensibilities might be warranted.

As Rossiter and Gibson (2011) argued, "The ambulatory occupation of urban space permits a myriad of unrealized possibilities to surface, triggering emotions and feelings that may lie dormant in many people" (p. 440). This adds another dimension to creativity. A number of studies have proved that, over time, walking and any physical activity improve thinking skills, both immediately and in the longer term. Walking specifically has been linked to creativity (Oppezzo & Schwartz, 2014).

For centuries, writers, poets, philosophers, and artists have developed their best ideas during a walk. To substantiate this intuitive link, Oppezzo and Schwartz (2014) ran four experiments that demonstrated how walking increases creative ideation in real time and shortly after. In one experiment, adults completed the Guilford's Alternate Uses (GAU) test of creative divergent thinking and the Compound Remote Associate (CRA) test of convergent thinking while seated and then when walking on a treadmill (indoors). Walking increased 81% of participants' creativity on the GAU, but only increased 23% of participants' scores for the CRA. In another experiment, Oppezzo and Schwartz generalized the prior effects to walking outdoors. A further experiment by these authors tested the effect of walking on creative analogy generation. Participants sat inside, walked on a treadmill inside, walked outside, or were rolled outside in a wheelchair. Walking outside produced the most novel and highest quality analogies. The effects of outdoor stimulation and walking were separable. Walking opens up the free flow of ideas, and it is a simple and robust solution to the problem of increasing creativity and increasing physical activity.

IMPLICATIONS FOR THEORY AND APPLICATION

Understanding the interplay between mobility and technology using ethnographic methods is key to the development of new systems and policies that may evolve from these understandings. The methodology used within this research may be applied across other design domains, where people engaged in research (in this specific case) would actively take part in physical activity in order to fully understand the more physical aspects of human activity that language, as a representational form, has difficulty in describing. This novel research offers its readers the opportunity to engage and take part in a process that more traditional approaches fail to offer and, in so doing, it aims to engender a more reflective and interpretive response to the writing that could lead to better theoretical and applied technical solutions that relate to using technology while on the move.

CONCLUDING REMARKS

There is an abundant literature in HCI on quantifying walking, that is, walking performed as a measurable activity in terms of number of steps, calories burned, or miles or kilometers walked. Similarly, the "quantified self" community (see Parviainen, 2016) is interested in generating numerical data from their physical activities, from food intake to waste and energy consumption. The obsession with numbers and quantitative measures has led to some discussion on an increasing commodification of walking, ultimately leading people to forget what it feels like to walk (e.g., Julian van Remoortere, cited in Amato, 2004). In the following, we suggest first a representational strategy that speaks of the importance of taking walking seriously. Second, we emphasize how our reflections in the paper may provide a groundwork for "walking for design" as a methodological implication for design.

Vitality in Walking Research and in Design Practice

We started this paper by asking the reader to take of her/his shoes and socks, maybe to take a short walk. Hopefully, this experience briefly allowed the reader to sense with her/his feet and perhaps reflect on how the ground felt. It might have felt uncomfortable or peculiar but perhaps also liberating. Our intention was to show what happens if we as researchers strive to preserve the aliveness of research, literally grounding research on walking in our (and the reader's) own experience. Vannini suggested that,

> non-representational research renders the liveliness of everyday interaction through methodological strategies that animate, rather than deaden, the qualities of the relation among people, objects, organic matter, animals, and their natural and built environments. In other words, non-representational ethnographies aim to be as full of vitality as the lifeworlds they endeavor to enact. (2015, p. 4)

Obviously, taking off one's shoes and socks is not a sufficient tactic for researchers or designers who want to engage with the choreographies of walking and digital technology. However, the attempt toward a more sensuous and embodied participation in life as it unfolds on foot should remind us—as researchers and ordinary humans—that there is more to walking than getting from Point A to Point B. Walking is about more than just ordered movement. It is more than facilitating the ergonomics of putting one foot in front of the other.

Preserving the vital qualities of walking is, we believe, key to a genuine engagement with walking and emergent ways of walking as a hybrid digital practice and as a felt experience. Vitality in representation attempts to avoid gross abstractions and might replace textual work with methods that concretely evoke such experiential qualities. This, in turn, can be turned into insights for design.

Designing for Walking, Walking for Design

Using strategies inspired by non-representational (or more-than representational; Lorimer, 2005) theory for relating what walking is and what walking can be opens up for a more alive form of scholarship. We find these strategies useful for framing design problems and design activities where precise and unambiguous representations of embodied practices might not necessarily be warranted.

We technology designers need to better understand how technology like mobile phones and wearable devices may subtly or grossly alter bodily ways of being and moving in the world, raising multiple questions. How are the movements of a walker's body synchronized with other walkers? How are we walkers following internal and external rhythms of our bodily movements and the environment around us? How do we feel the sense of wear, accomplishment, and pride but also the slight shocks and ensuing stiffening of muscles brought on by the distractions from virtual layers of connectivity? How do we share stories of our movements around on foot? How do we sense and act on and in the landscape as we walk? How might digital technologies afford us a sense of embodied fluency but also contribute to mishaps or disaster? Perhaps we misstep as we search for digital infrastructures or walk along with our eyes fixed on the small screen in our hands. How do we appropriate technologies into walking? How do we wear it, protect it from mishaps, stay in rhythm with the device (or vice versa) and other device users, or share our digital footprints mindfully, become creative, and integrate digital technologies gracefully into walking practices?

In this paper we have used our own examples from walking and tried to inspire designers to record, reflect on, and generally take their walking seriously as means of framing their interventions and design practices. There are a number of vocabularies describing the specific qualities of interactive artifacts (e.g., Isbister & Höök, 2009; Moen, 2005) that are useful in considering the many questions and issues raised in this paper. However, our goal in this paper is aimed at shifting the focus towards some basic qualities of walking as a ubiquitous and mundane form of human mobility that increasingly provides the context for using mobile computing. Therefore, we have developed a partial vocabulary of six characteristics with which to engage with qualities of pedestrian mobility: sensuality; rhythm, synchrony, and balance; coincidence and narrative; hybridity; ecology of connection; and creativity.

We believe that designing for mobility, wearability, or walkability can usefully be improved by walking for design. Designers of mobile technology should walk more. Paying attention to the detailed variety and sensuous nature of walking practices is useful and relevant to design. Dix's work (Dix, 2013; or walking, as recounted above) stands out as a particularly sustained engagement with walking practices and technologies. In this paper we have complemented some aspects of Dix's walk (or work) with an initial and open vocabulary for talking about qualities of walking.

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CHOREOGRAPHIC INSCRIPTIONS: A FRAMEWORK FOR EXPLORING SOCIOMATERIAL INFLUENCES ON QUALITIES OF MOVEMENT FOR HCI

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Abstract: *With the rise of ubiquitous computing technologies in everyday life, the daily actions of people are becoming ever more choreographed by the interactions available through technology. By combining the notion of inscriptions from actor–network theory and the qualitative descriptors of movement from Laban movement analysis, an analytic framework is proposed for exploring how the interplay of material and social inscriptions gives rise to movement patterns and behaviors, translated into choreographic inscriptions described with Laban effort and shape. It is demonstrated through a case study of an affective gesture mobile device. The framework provides an understanding of (a) how movement qualities are shaped by social and material inscriptions, (b) how the relative strength of inscriptions on movements may change according to different settings and user appropriation over time, and (c) how transforming inscriptions by design across different mediums can generate action spaces with varying degrees of openness.*

Keywords: *choreographic inscription, movement quality, actor–network theory, Laban movement analysis.*

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INTRODUCTION

Everyday actions of people are becoming ever more choreographed by the interactions available through ubiquitous computing technologies. As these technologies become embedded in objects and the environment, close to the entire range of human actions, movements and gestures that make up daily life become available for input and computational processing. This poses a challenge to the fields of human–computer interaction (HCI) and interaction design. HCI now has specializations such as tangible, natural, and proximal interaction that include an explicit movement dimension. But when is movement a design priority in itself? Most applications require some form of human movement to take place for interaction but often in the service of achieving a goal or task that is not explicitly about movement itself. In recent years, applications have appeared where movement is the central focus of the system, often for games, sport, dance, exercise, and rehabilitation. Even if movement is not the central or explicit focus of the system, the fact that movement is involved at some level to facilitate actions and interactions with and through technology brings a new significance to the quality and spectrum of movements people perform in daily life.

We are interested in examining how material and social factors enable or constrain movement patterns and behavior, whether intentionally by design or as a side-effect. In this paper, we propose to do this through an analysis combining actor–network theory and Laban movement analysis. Our focus goes beyond functional movements to consider the quality, expressivity, creativity, and kinesthetics of movement often treated as choreographic in nature. By combining the notion of inscriptions from actor–network theory and the qualitative descriptors of movement from Laban movement analysis, a new concept for HCI, *choreographic inscriptions*, is put forward for inscribing qualities of movement by design.

The notion of inscriptions is often employed together with that of translations. In very simple terms, they correspond to acts of writing and reading, respectively. They are key terms of actor–network theory (Akrich & Latour, 1992) to render visible the interconnectedness between entities and transformations taking place at multiple levels during interactions between entities. While acts of inscribing onto something generate various programs for action, acts of translating something may produce deviations from the inscribed programs for action. Therefore, as Hanseth and Monteiro asserted, the notion of inscription allows a balance between technological and social determinism:

> Balancing the tight-rope between, on the one hand, an objectivistic stance where artefacts determine the use and, on the other hand, a subjectivistic stance holding that an artefact is always interpreted and appropriated flexibly, the notion of an inscription may be used to describe how concrete anticipations and restrictions of future patterns of use are involved in the development and use of a technology. (Hanseth & Monteiro, 1997, p. 3)

The notion of choreographic inscriptions aims to provide a way of framing and conceptualizing human movement beyond the purely functional towards an understanding of the field of potential movement quality and expression enabled or constrained through designed artifacts and the social world in which they are embedded. The term *choreography* is traditionally defined as the composition or structuring of movement in space and time (Butterworth & Wildschut, 2009). It also speaks to the aesthetic, creative, and vitality-generating aspects of movement (Fraleigh, 1987), the qualities that foster a more nuanced and articulate human movement expression and quality of life. In etymological terms, choreography is writing dance or, as anthropologists more broadly define it, "writing movement" (Williams & Farnell, 1990). Choreography has been understood as inscribing moving bodies in space (Martin, 1995) and, by extension, into other media, including digital technologies (Lycouris, 2009). The transfer of choreographic thinking onto materials other than the body can be considered a form of inscription (in the actor–network theory sense of creating programs of action), echoing Forsythe's (2009) contention that "A choreographic object is not a substitute for the body, but rather an alternative site for the understanding of *potential instigation and organization of action* to reside" (p. 4; emphasis added) or, as Allsopp and Lepecki (2008, p. 4) described, "a means of inscribing bodily, social, and non-human movement in cultural, social, political and personal space." This expanded view of choreography as inscribing movement in dimensions and arenas other than the purely material connects choreographic approaches to considerations of the immaterial forces and influences acknowledged by actor–network theory.

The analysis of movement is well established in anthropology, science, and dance. Movement can be interpreted in the sociocultural frame of patterns of social and spatial interaction between people. The most well-known examples are Goffman's (1959) theory of social interaction based on a theatrical metaphor and Hall's (1968) proxemics. Movement has been conceptualized as nonverbal communication, most notably in Birdwhistell's (1970) kinesics, Kaeppler's (1978) kinemes and morphokines, and as meaning in patterned and structured movement systems such as sports games, religious rituals, and dance (Reed, 1998; Williams, 1991). Whereas these systems have tended to foreground the social and semantic dimensions of human behavior, interaction analysis (Jordan & Henderson, 1995) in HCI studies aimed to integrate both social and material aspects of human activity and interaction, with a particular focus on technology use. Actor–network theory differs from these approaches by its emphasis on the emergent and co-constructive characteristics of human–technology relationships and its symmetrical treatment of human and nonhuman actors.

Dance and movement notations focus on the changing patterns of motion in the body and between bodies in relation to parameters of space and time (Guest, 1984). Laban movement analysis has been used in dance and movement studies for observing both natural and choreographed movement and for exploring and choreographing movement. It continues to be used in fields traditionally associated with the physical body, such as dance studies (Guest, 1984; William & Farnell, 1990), physical therapy (Bartenieff & Lewis, 1980), and drama (Newlove, 1993), and also has been applied in anthropology (Farnell, 1999; Lewis, 1995). Since the late 1970s, Laban movement theory has been applied to various fields of computing, such as motion recognition, computer animation, and artificial intelligence (e.g., Badler & Smoliar, 1979; Camurri et al., 2000; Schiphorst, Lovell, & Jaffe 2002; Swaminathan et al., 2009). More recently, it has been applied in the design of interactive products and systems for its ability to capture the relations between movement, expression, and emotion (Fagerberg, Ståhl, & Höök, 2003; Jensen, 2007; Ross & Wensveen, 2010). It is becoming recognized as the primary crossdisciplinary shared language among researchers working at the junction of experiential and computational models of movement (e.g., Larboulette & Gibet, 2015; Lockyer, Bartram, Schiphorst, & Studd, 2015).

Several existing design frameworks provide ways of framing, conceptualizing, and interpreting movement (Bongers & Veer, 2007; Eriksson, Hansen, & Lykke-Olesen, 2007; Fogtmann, Fritsch, & Kortbek, 2008; Hornecker & Buur, 2006; Hummels, Overbeeke, &

Klooster, 2007; Klooster & Overbeeke, 2005; Ross & Wensveen, 2010; Schiphorst, 2007). Choreographically oriented design approaches include the choreography in interaction framework (Hummels et al., 2007; Klooster & Overbeeke, 2005) and the interaction quality framework (Ross & Wensveen, 2010), arising out of product design with an interest in the design of moveable products inspired by human movement. The kinesthetic interaction framework (Fogtmann et al., 2008) offered a range of concepts for thinking about movement in design (expressive meaning, kinesthetic empathy, movability, explicit/implicit motivation), which overlap with choreographic intentions. Several frameworks provide mapping strategies for interaction with technology and support of various kinds of movement-based activities (Benford et al., 2005; Loke & Robertson, 2013; Rogers & Muller, 2006; Wensveen, Djajadiningrat, & Overbeeke, 2004). Although these frameworks offer concepts for sensitizing the qualities of movement for interaction with technology and methods for generating and evaluating models, prototypes and solutions for movement-based interaction, less attention has been paid to how qualities of movement are inscribed—in varying strengths, in different technology design choices.

In the following sections, we briefly introduce the key concepts and terminology of actor–network theory and Laban movement analysis relevant to this paper. The actor–network concepts of inscription and translation are compared with established understandings in HCI of the concepts of affordances, constraints, and appropriation. We then present and explain our choreographic inscription analytic framework. The framework is illustrated through application to a selected case study of a gesture-based interactive technology, the eMoto affective gesture system (Fagerberg, Ståhl, & Höök, 2004). This case was selected as an example of an interactive technology that has not yet been widely adopted but presents an exploration of future likely possibilities of gesture-based interactions with mobile devices. The published work on the development of the eMoto system provides a solid foundation for our analytic purposes, especially because the authors of the eMoto system have utilized Laban effort and shape in combination with Russell's (1980) circumplex of emotion to derive their affective gestural plane model. A discussion is opened on a number of key insights, including how the relative strength of inscriptions may change according to different social settings and user appropriation over time, and how it is possible to translate inscriptions across different mediums by design to achieve desired programs of action. These insights are elaborated through hypothetical extensions of the eMoto system, positioned within a mapping of open- and closed-action spaces. We conclude by summarizing the key contributions of the paper.

ACTOR–NETWORK THEORY AS A RELATIONAL LENS

Actor–network theory (ANT) evolved out of the efforts of scholars of science and technology studies, notably those of Michel Callon, Bruno Latour, and John Law, in the 1980s. The etymology of the term is French: *acteur réseau*. Latour (1990) noted that the term *réseau* was first used by Diderot to describe matter and bodies without being confined to the Cartesian divide between matter and spirit. In their ethnographic study of practices in scientific laboratories, during which they analyzed the daily practices undertaken in a neuro-endocrinological laboratory in California, Latour and Woolgar (1979) demonstrated how scientific facts are socially constructed in a network of relations between people, inscription devices, and articles rather than being discovered.

According to Law (1999, p. 3), ANT may be understood either as a semiotics of materiality or as a material-semiotic approach: “It takes the semiotic insight, that of the relationality of entities, the notion that they are produced in relations, and applies this ruthlessly to all materials—and not simply to those that are linguistic.” Therefore, relationality in ANT is not confined to explaining linguistic units but is extended by including any kind of human and nonhuman entity. The main area of interest for ANT researchers is the emergence and transformation of relations and patterns of relations. Analytically, humans and nonhumans are treated symmetrically, which allows researchers to understand the processes of becoming: becoming a kind of human, becoming a kind of nonhuman, and becoming a kind of collective of humans and nonhumans. Both humans and nonhumans can be authentic actors provided that they are capable of doing things and/or modifying “a state of affairs by making a difference” (Latour, 2005, p. 70–71).

Key Concepts of ANT

Mol (2010) argued that ANT may be seen simply as a list of terms. While stressing that there are many important terms in ANT, we limit the discussion to a few relevant terms only.

Actor, Actants, and Entities

According to ANT scholars, any entity that acts or makes a difference can be defined as an *actor*. Latour proposed the term *actant* in order to overcome the cultural anthropomorphic connotations of the term actor. Scholars of ANT have provided various definitions of the two terms. For example, an actor (or actant) can be “any element which bends space around itself, makes other elements dependent upon itself and translates their will into a language of its own” (Callon & Latour, 1981, p. 286). Latour (2005, p. 71) claimed that “any thing that does modify a state of affairs by making a difference is an actor—or, if it has not figuration yet, and actant.” In general, anything can be considered as an actor/actant provided that it is able to make a difference and leave a trace.

Inscriptions and Translations

The power of inscription and translation, two important concepts of ANT, generates from their broad metaphorical scope and intertwined conceptualization. Metaphorically speaking, inscribing can be understood as an act of writing in or on anything. When an actor writes something, the written thing, that is, the inscription, influences the relations and roles of its actors to varying degrees. Any human or nonhuman actors, their effects, and their relations can be viewed as inscriptions for a situation. Inscriptions join in a collective of actors and influence the actors’ capacities for action. Thus, a collective of human and nonhuman actors may be viewed as a collective of inscriptions that have the capacity to affect each other. In this respect, all interactions among the actors become processes of translation: Actors translate (read) the interests of other actors or their programs of action.

Akrich (1992) noted that the technical content of the objects embodies a script similar to a film script that defines the actors, their roles, and the settings. A script involves, in varying degrees of strength, programs of action that are translated into practice (Akrich, 1992; Callon, 1986). However, these inscribed programs of action may not succeed should the translation processes vary; in addition, actual interactions between entities may unfold in unexpected ways. There is a mutual influence between interacting entities: Objects enable or constrain the actions of humans, but, at the same time, humans reshape the objects and their relationships with them.

The strength of an inscription may vary from very strong, that is, imposing one particular inflexible program of action, to very weak, offering many flexible programs of action. Latour (2005) provided an example of the progressively increasing strength of an inscription. The case cited is that of a hotel manager who wants his/her guests to deposit their room keys at the reception desk when departing the hotel. The manager first uses oral communication, then written notices to invite the desired behavior. However, neither form of communication implemented to define a desired program of action proves successful. Finally, a metal weight is attached to the room keys, an inscription that proves successful. While the first two inscriptions were weak, the final one was strong enough to impose the desired behavior on the hotel guests.

Translation has been used to explain various processes during the construction of a collective or network. Callon explained that translations are processes within which actors relate to one another and "the identity of actors, the possibility of interaction and the margins of manoeuvre are negotiated and delimited" (1986, p. 203). According to Murdoch, translation involves "the processes of negotiation, representation and displacement which establish relations between actors, entities and places" (1998, p. 362).

In effect, translations and inscriptions are intertwined processes. The objects of translation may include the inscriptions embodied in materials or the interests or intentions of some actors. In fact, the very act of inscribing something involves an act of translating. An actor translates its interests to different mediums, which can be anything from words and gestures to objects and laws and may be material or semiotic. These mediums embody the interests of the actor through the inscriptions, as in the case of the hotel keys. Therefore, inscriptions may be defined as embodied translations in a medium that will, in turn, be further translated by other actors in practice. This idea of translating inscriptions from one medium to another will be taken up in the Discussion section but from a design perspective.

CONSTRAINTS, AFFORDANCES, AND APPROPRIATION

In the related fields of HCI and interaction design, there are similar notions to inscriptions, such as constraints (Norman, 1998), affordances (Gaver, 1991; Norman, 1998), and appropriation (Anacleto & Fels, 2013; Dix, 2007). Norman (1998) explained that constraints can be viewed as limitations on the possible set of actions. Constraints can be defined by material properties of an object (physical constraints), social acceptability in situations (cultural constraints), a user's knowledge of situations (semantic constraints), or a user's reasoning of situations (logical constraints). The concept of affordance was originally developed by J. J. Gibson (1986) to explain how action possibilities emerge out of a relation between the material properties of a physical object and the capabilities of a living entity. For example, if an object has a large enough horizontal flat surface raised 50 cm from the ground, it may afford sit-on-ability for an adult person. However, the same object may afford climb-on-ability for a small child. Affordance is a powerful relational concept to understand how the space of possibilities is constructed by the properties and capabilities of an object and subject, respectively.

Although constraints and affordance are similar in terms of their role in shaping actions, there are some important differences between the two. While constraints are generally attributed to an entity or situation, affordances are attributed to the relationships between entities and emphasize the emergent and relational nature of possibilities for action. Constraints deal with the limitations of an entity or a situation on actions whereas affordances focus on both the enabling and constraining aspects of relationships on actions. The concept of appropriation, on the other hand, refers to the cases in which interpretation and usage of technologies deviate from their original purpose. Appropriation allows a less deterministic attitude to be developed towards the relationships among humans and other entities, in particular, technologies. Despite the fact that constraints, affordances, and appropriation are valuable concepts embracing, in varying degrees, the relational aspects in the possibilities for action, their focus is mainly upon unidirectional aspects from humans to technology in human–technology relations. In other words, their primary concern is either humans' interpretations of technology or humans' actions on technology, but is not about their mutual effects or entanglement.

The power of inscription and translation is attributable to their metaphorical scope and their intertwined conceptualization according to which an act of inscription is an act of translation as well. While the broad metaphorical scope facilitates application of the concepts to the relations between practically any entities, the intertwined conceptualization allows a balance between technological and social determinism. The notions of inscription and translation do not privilege any actors in their framing of possibilities for action. Humans and nonhumans are treated as symmetrical in analytic terms. It is possible to consider the notions of inscriptions and translations as an overarching pair of concepts unifying the concepts of constraints, affordances, and appropriation in the sense that they allow us to become aware of (a) the enabling or constraining aspects of relationships on actions (that is, affordances), (b) the constructed nature of affordances, (c) the actors taking part in the creation of affordances, and (d) the possibilities of deviations from affordances. Ultimately, employment of inscriptions and translations captures the mutual co-constructive nature of human–technology relationships and enables interaction designers to integrate a relational sensitivity into their design thinking at almost every decision-making step.

Latour (1992) explained how a simple case of closing doors involves complex translations and delegations between human and nonhuman actors. In his example, he compared a regular door, a door with a doorman, a door with a spring-based automatic door closer, and a door with a hydraulic door closer. One of his main points was that each alternative creates a very different inscription or program for action of opening, passing through, and closing the door. For instance, a door closer with a spring mechanism requires a very specific and quick way of passing through the doorway, otherwise it may slam in one's face. On the other hand, a door with a hydraulic closer retains the energy it receives from a person's movement and slowly releases it. Therefore, it does not require passers to be very quick in their movements. However, it does require more power to operate and may create an obstacle for children or older people with limited muscular power.

LABAN EFFORT AND SHAPE FOR DESCRIBING QUALITIES OF MOVEMENT

Laban movement analysis (LMA) and its companion Labanotation form a system and language for observing, describing, analyzing, and notating all forms of human movement. It was originally developed by choreographer Rudolph Laban (1971) in the 1920s and was extended primarily by Knust (see Guest, 1984), Hutchinson (1977), Lamb and Watson (1979), and Bartenieff and Lewis (1980). It offers a framework and vocabulary for describing the structural and physical characteristics of the moving body, the use of space, and the dynamic, qualitative, and expressive aspects of movement through four major components: body, effort, shape, and space. We focus here primarily on the effort and shape components because they are intended for description of the qualities of movement, including the inner attitude of the mover. These two components of movement focus on "the changing patterns which occur in the ebb and flow of energy within the body" (Hutchinson, 1977, p. 12). For example, in dance choreography, this form of description conveys the aesthetic, emotional, and expressive qualities of the dance.

Effort

Effort (or the energy content) of a movement is described in the motion factors of weight, space, time, and flow, together with how a person indulges in or resists each factor. Each factor is represented by two polarities: Weight (light/strong), Space (direct/indirect), Time (sudden/sustained), and Flow (bound/free). Laban (1971) defined an effort element in terms of two components: the measurable, objective aspects of resistance, speed, direction, and control and the personal and classifiable aspects of levity, duration, expansion, and fluency. The first component relates to the properties of movement that can be measured by an outside observer. The second component relates to the movement sensation, that is, qualities of psychosomatic experience. Laban (1971, p. 81) described the significance of movement sensations as, "While in functional actions the movement sensation is an accompanying factor only, this becomes more prominent in expressive situations where psychosomatic experience is of utmost importance." For this paper, we restrict the analysis to the observational perspective, how movements are observed from an external point of reference to the body.

There are eight basic effort actions derived from the motion factors of weight, space, and time (flow is excluded). A diagram of the basic effort actions is illustrated as an effort cube (see Figure 1), otherwise known as the dynamosphere (Newlove, 1993). For example, a Float effort action is light in weight, indirect in space, and sustained in time. By changing the polarity in one factor, say from indirect to direct in space, the effort action becomes a Glide. The effort cube is a useful reference for quickly locating and identifying specific movement qualities in a field of movement potential, delineated by eight basic actions with names that refer to familiar actions in daily life.

Shape

Shape describes the spatial shaping of form—growing, shrinking, or carving patterns in space. It describes the expressiveness inherent in the form of a movement. Shape analysis was developed primarily by Lamb and Watson (1979). They described the shaping process in this way:

> The actual process of variation, which results in a succession of differently sculpted positions, can be described as a sculpturing, or shaping process. If we wish to become more aware of the shape of a person's posture pattern, as he [*sic*] dresses himself, or greets friends at a party, or elbows his way around a store, for example, it helps to imagine that all his joints are emitting vapour trails as though they contained jet engines. (Lamb & Watson, 1979, p. 49–50)

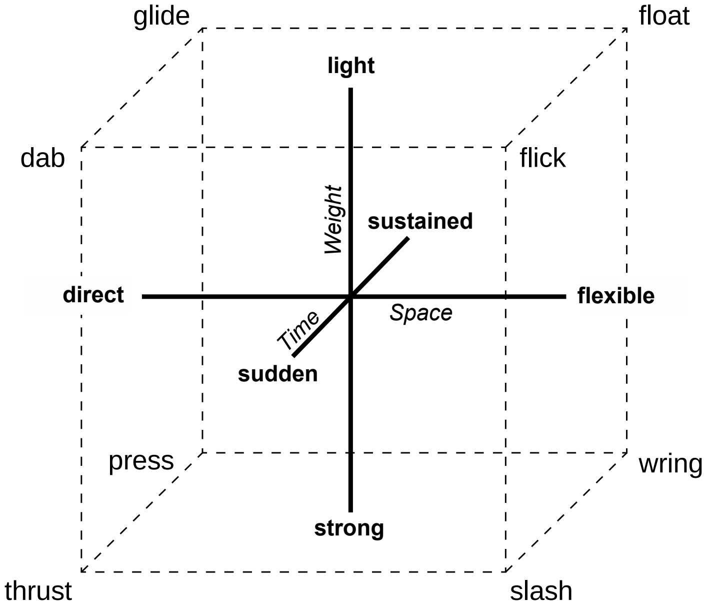

Figure 1. The Laban effort cube maps the effort dimensions of weight, space, and time along axes into a three dimensional field delineated by eight effort actions on the vertices of the cube.

The spatial shaping of the body can be analyzed in terms of what forms the body makes and the relation of the body to itself and its environment. Shape analysis provides a set of descriptors for dynamic, fluctuating shape characteristics, classified into categories of Shape Form, Shape Flow, Shape Quality, and Directional Shape. Shape form describes the static shapes that the body takes, for example, pin-like, wall-like, ball-like, or screw-like. Laban (1971, p. 70) defined these four terms in relation to the organization of parts of the body as the (a) spine and its pin-like extension, (b) right/left symmetry of body and its wall-like surface, (c) limbs, together with their respective trunk regions curling and circling in ball-like shapes, and (d) shoulder-girdle and pelvis twisted against one another in screw-like fashion. Shape flow supports the body changing its form only in relationship to itself, for example, when breathing, daydreaming, or being self-involved (Bradley, 2009).

Shape quality describes the attitudinal process changing the shape of the body, for example, opening or closing or growing or shrinking, indicating the degree of extension or contraction in the body. More specific terms include rising and sinking (along the vertical axis of the body), spreading and enclosing (along the horizontal axis), and advancing and retreating (along the sagittal axis). Directional shape is when the body is directed towards some part of the environment, other person, or object. It can be spoke-like (e.g., shaking hands) or arc-like (e.g., painting a wall). The spatial intent of a movement determines the particular spatial shape that is produced as the movement unfolds. For example, the action of pulling a fishing net out of the water has a spatial intent that is directed along a radial line from the center of the body to the periphery where the hands hold the net. The related spatial shape of the body is one that expands and contracts along the path dictated by the spatial intent as the person repeatedly pulls the net towards the body (Bartenieff & Lewis, 1980). Together, effort and shape capture the dynamic process of human movement and provide a vocabulary for describing the salient features of the movement that can form part of a design language enabling communication and exploration of movement qualities.

THE CHOREOGRAPHIC INSCRIPTION ANALYTIC FRAMEWORK

In our bid to facilitate a movement-focused sensitivity to technology design, we bring together ANT's key concepts of inscriptions and translations and LMA's effort and shape descriptors into a single analytic framework focusing on choreographic inscriptions. While ANT's notions of inscriptions and translations allow us to bridge design decisions with movements enabled or disabled in practice, LMA provides us with an analytical model to understand movement in terms of various qualities of a choreographic nature. ANT typically works with an analytic unit of an action. Here we are interested in placing a movement lens on these actions, thus bringing to the fore the significance of the quality of inscribed movement patterns and potentials.

The framework consists of three dimensions: material, social, and choreographic inscriptions. For each inscription, the strength varies along a spectrum of weak to strong. The first dimension, material inscriptions, deals with the physical properties of an object or setting and the ways in which those properties act as strong or weak sources of influence on actors' potentials for action. It is possible to consider material inscriptions as constituents of affordances embodied by objects or the environment. The second dimension, social inscriptions, refers to immaterial forces such as social norms, informal codes of conduct, and formal rules and regulations regarding social behavior belonging to a particular social setting.

The third dimension, choreographic inscriptions, is a translation of the material and social inscriptions onto the movement possibilities of human bodies. It characterizes the actions in terms of movements using the qualitative vocabulary from Laban effort and shape. The dominant patterns of movement enabled or constrained by a particular interactive technology are identified. The character of the energy present in a movement gesture is described with the effort dimensions of weight, space, time, and flow, and/or summarized with an effort action (see effort cube, Figure 1). The relative strength, control, and timing of energy expenditure are captured in the effort analysis. For describing the ongoing dynamic shaping of the body in space and time, the descriptors of shape form, directional shaping, and shape quality are used, where appropriate. The choreographic inscription description is supplemented by visual illustrations of the spatial shaping of the human body. This visual aid helps to convey at a glance the range and type of spatial shaping generated by interaction with material artifacts in specific social settings.

It is important to point out that actual movement can never be reduced to a single LMA descriptor. The effort and shape descriptions are meant to be indicative only and attempt to capture the salient, observable properties of the movement in terms of expressive energy content and spatial shaping of the body. The abstract descriptions of effort and shape are translated in practice and may vary according to an individual person's state of embodiment at a particular point in time.

APPLYING THE FRAMEWORK: THE CASE STUDY OF eMOTO

In this section, we apply our analytic framework to a selected case study of a gesture-based interactive technology, the eMoto affective gesture system (Fagerberg et al., 2004). In brief, the eMoto system is an emotional text messaging service built on top of a Sony Ericsson P900 mobile terminal. Users can emotionally enhance their text messages by adding an animated background that corresponds to the emotion they wish to communicate. The affective background is first created by the user interacting with a stylus (equipped with an accelerometer and pressure sensor) to record an affective gesture through shaking, swinging, and squeezing the stylus. After they have performed the affective gesture, they can then navigate through a circle of animated colors and shapes to select what they perceive to correspond visually to their emotional expression. This message is sent to someone who is then free to interpret the emotional content of the message.

The authors of the eMoto system have published several papers documenting the study of affective gestures (Fagerberg et al., 2003), the subsequent design (Fagerberg et al., 2004), and user evaluation (Sundström, Ståhl & Höök, 2005) of the eMoto system. We refer to these publications as resources for our analysis. We have reused two usage scenarios from the user evaluation study (Sundström et al., 2005)—the Perfect Job and the Racist Doorman—as a starting point for our analysis. Of the four scenarios in Sundström et al.'s (2005) user evaluation study, these two exhibited the greatest amount of body movement by participants; the other two resulted in very little body movement and are thus not particularly useful for demonstrating dynamic effort and shape qualities of movement. We re-present the results of their study in a new format here, an inscription analysis table, by extending the analysis to include more in-depth movement analysis in terms of Laban effort and shape descriptors and the

Table 1. Inscription Analysis Table for Usage Scenario: The Perfect Job.

Usage Scenario	**The Perfect Job**		
(from Sundström et al., 2005)	You write to tell your boyfriend that you got the job you applied for even though there were over a thousand applications.		
Emotional Expression	**Arousal (high/low) Valence (pleasure/displeasure)**	**Gesture**	**Setting (private/public)**
Excited	High & Pleasure	Wavy movement high in the air	Private: At home
Material Inscriptions	**eMoto system (weak inscription)**		
	The strength of the material inscriptions is intentionally weak, based on a desire for users to be able to perform affective gestures of their choice for specific emotions. However, the design of the input devices (stylus, mobile phone) will lead to some common movement responses, captured in the choreographic inscriptions. Holding the stylus requires a certain way of grasping it that will influence the expression of the total body gesture. The eMoto system offers shaking, swinging, and squeezing gestures through interaction with the stylus. The squeezing gesture is limited to the hands, whereas the shaking and swinging gestures can be enacted by the arm, with more or less involvement of the whole body. The accelerometer affords the user a waving action to express an excited emotion, together with gentle squeezing of the pressure sensor.		
	Physical environment (semiweak inscription)		
	When sitting at a desk (as was the case in the user evaluation study), the proximity of furniture and devices may constrain the expressive movement.		
Social Inscriptions	**Setting (weak inscription)**		
	When alone at home, there is likely to be less formality and inhibition compared to being in the company of people in the same environment.		
Choreographic Inscriptions	Effort	The effort graph corresponding to Excited is strong in weight, flexible in space, quick in time, and fluent in control of flow (see Fagerberg et al., 2003). This can also be classified as a slash-like effort action (see effort cube, Figure 1). This gesture tends to have a releasing in space quality.	
	Shape	For the example in the user evaluation study, the person is sitting at a desk and performing a hand-waving gesture above her head. The shape form is pin/ball-like shifting to wall/ball-like, the quality is spreading/enclosing, and the directional shaping is arc-like as the arms wave above the head. See visual illustrations of spatial shaping in Figure 2 (i) to (iii).	

implications of material and social inscriptions on the resulting actions. We have limited our analysis to the gestures performed and documented in the user evaluation study, although these are part of a broader range of interactions involved in the total message composition process. Inscription analysis tables for the two usage scenarios are given in Table 1 and Table 2.

The first five fields in the table (usage scenario, emotional expression, arousal/valence, gesture, setting) are taken from the user evaluation study (Sundström et al., 2005) and the affective gestural plane (Fagerberg et al., 2003). We have added the last three fields: material inscriptions, social inscriptions and choreographic inscriptions. Material inscriptions and social inscriptions contain descriptions of how these two types of inscription influence the resulting performance of affective gestures by the users of the technology. The relative strength of each inscription is estimated and discussed. The choreographic inscriptions field contains Laban effort and shape descriptions for the observed gestures from the user evaluation study. Illustrations of spatial shaping for each usage scenario are given in Figure 2 and Figure 3.

Table 2. Inscription Analysis Table for Usage Scenario: The Racist Doorman.

Usage Scenario (from Sundström et al., 2005)	**The Racist Doorman** You write to tell a friend that you and another friend could not get into the bar because of a racist doorman.		
Emotional Expression	**Arousal (high/low) Valence (pleasure/displeasure)**	**Gesture**	**Setting (private/public)**
Angry	High & Displeasure	Hard Shaking	Public: Outside, Near Bar
Material Inscriptions	**eMoto system (weak inscription)** The strength of the material inscriptions is intentionally weak, based on a desire for users to be able to perform affective gestures of their choice for specific emotions. However the design of the input devices (stylus, mobile phone) will lead to some common movement responses, captured in the choreographic inscriptions. Holding the stylus requires a certain way of grasping it that will influence the expression of the total body gesture. The eMoto system offers shaking, swinging and squeezing gestures through interaction with the stylus. The squeezing gesture is limited to the hands, whereas the shaking and swinging gestures can be enacted by the arms, with more or less involvement of the whole body. The accelerometer affords the user to perform a shaking action to express an angry emotion, together with hard squeezing of the pressure sensor.		
	Physical environment (weak inscription) The interaction takes place in an open space with little physical impediment to movement.		
Social Inscriptions	**Setting (semistrong inscription)** The strength of the social inscription is defined by the tension between various social factors. Given the incident takes place in a public location and the user may wish to text immediately while in a vicinity near the bar, the affective gesture performed may be tempered by being in a public space. On the other hand, as he/she is in the company of a friend, this may support him/her in being more openly physically expressive than if in the presence of strangers. The presence of other people provides a strong influencing factor on physical conduct (Goffman, 1959).		
Choreographic Inscriptions	Effort	The effort graph corresponding to Angry is strong in weight, flexible in space, quick in time, and bound in control of flow (see Fagerberg et al., 2003). This can also be classified as a somewhat slash-like effort action (see effort cube, Figure 1). This gesture tends to be contained and tense.	
	Shape	The gesture observed in the user evaluation study was confined to an arm gesture, composed of a short, sharp, rhythmic up/down shaking action. The shape form is pin-like, and the directional shaping is somewhat spoke-like, with the active arm held in front of the torso. The variation in spatial shaping is low, with most of the movement occurring in the active hand and lower arm, as the user directs his/her emotion into squeezing and shaking the stylus. See visual illustrations of spatial shaping in Figure 3.	

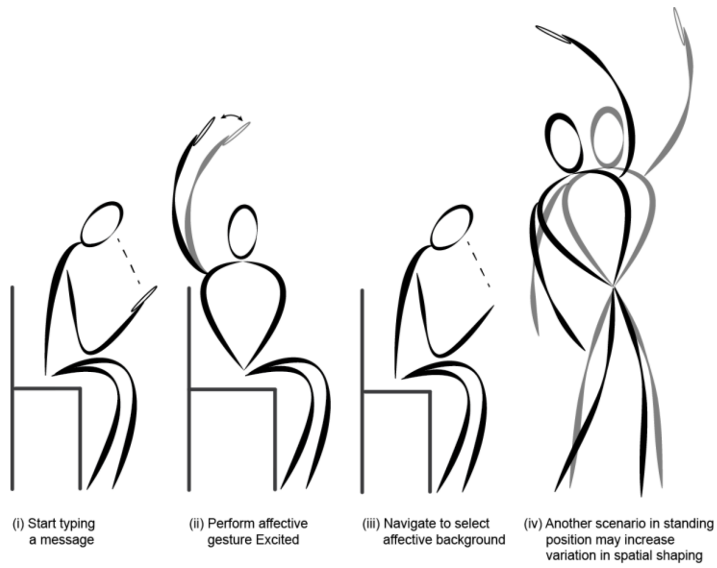

Figure 2. Spatial shaping for the excited emotion in the Perfect Job scenario: The dominant shaping patterns of the body are illustrated for the main interactions with the device while sitting in a private home setting, ranging from a fairly static posture in Steps i and iii to a more physically expressive movement of waving the arms above the head in Step ii. Step iv suggests how even more physically expressive movements may be obtained by standing instead of sitting**.**

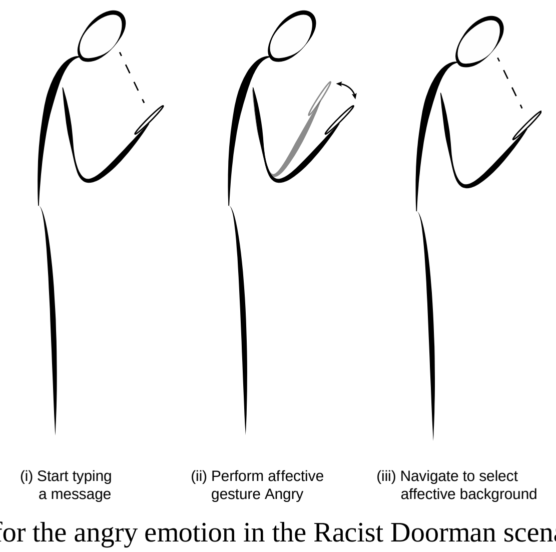

Figure 3. Spatial shaping for the angry emotion in the Racist Doorman scenario: The dominant shaping patterns of the body are illustrated for the main interactions with the device, which are limited in this case to a gestural shaking action of the arm while holding the device in a public space setting.

DISCUSSION

The choreographic inscription analytic framework enables thinking through how inscriptions evolve over time and are translated across different mediums, either by user appropriation or by design. By varying the strength of the material and social inscriptions, designers can explore how this affects the qualities of movement considered socially acceptable and available for communication and expression. We illustrate our points through a hypothetical redesign of an eMoto application situated in different social settings across four action spaces with varying degrees of openness. First we discuss in general terms convergences and deviations of behavior in open and closed action spaces. Then we examine how inscriptions and translations can be transformed in strength through user appropriation or the creation of new technology-enabled social protocols— both instances where the designer has little control. Finally we explore how, through intentional design acts material, social and choreographic inscriptions can be deliberately transformed resulting in shifts across action spaces with different action possibilities.

Open and Closed Action Spaces

It is possible to see the human–technology relations on a continuum of openness and closeness enabled by weak and strong inscriptions, respectively. Weak inscriptions usually generate an open action space in which there are very few restrictions on the movements of humans whereas strong inscriptions facilitate a closed action space in which there are many movement constraints. Material and social inscriptions can be employed to generate a diagram involving four action spaces with varying degrees of openness (Figure 4). This diagram is useful for understanding how shifts among these spaces of possibilities may take place through evolving inscriptions and translations.

In the diagram, the dark gray space shows strong inscriptions on both social and material inscriptions, indicating strong restrictions on body movements. In contrast, the light gray zone indicates weak inscriptions on both dimensions, resulting in very little movement restrictions. The other two spaces can be considered semiopen spaces in which a combination of weak and strong inscriptions exists. Although a deterministic relationship between the strength of inscriptions and

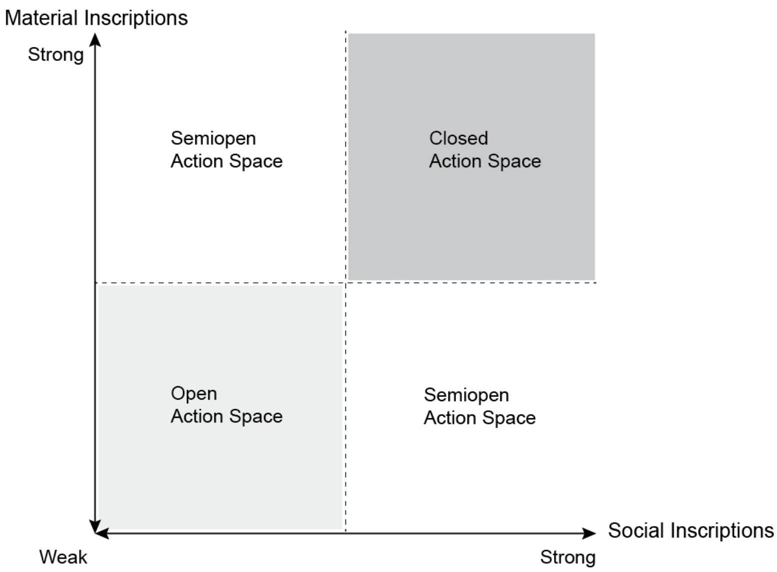

Figure 4. Mapping of action spaces to inscription strengths illustrating the range of open to closed action spaces relative to weak/strong inscriptions.

the observed movements can exist in many cases, there is a possibility that humans may perform unexpected movements. Our framework enables designers to deal with such nondeterministic situations. When one thinks about human–technology relations in terms of inscriptions, two kinds of nondeterministic instances are possible: convergences and deviations. These two instances are acts performed against weak and strong inscriptions respectively (see Figure 5).

In an open action space with few constraints, human movements usually start with very exploratory movements. In this discovery or getting-to-know phase, a movement vocabulary or some movement patterns are developed, and it is possible to see that the experience with these newly discovered movements start to act like inscriptions, shaping the future interactions in the same space. Therefore, the action space is no longer open as the movement experience in the space strengthens what were previously weak inscriptions. Convergence refers to those instances where human actors move from an open action space to a closed action space through the generation of self-defined inscriptions.

In an open action space with little or no guidance, information, or constraints on what movements to perform, there might be a tendency to stabilize or get to know such a chaotic or unknown system. In fact, the act of getting to know something is an act of generating a self-defined inscription. A series of workshops conducted by Kocaballi, Gemeinboeck, and Saunders (2010) demonstrated how convergence takes place in an open action space. In the workshops, pairs of participants engaged in game-like activities, each using a novel wearable device to communicate with the other in nonverbal ways. The participants negotiated less and performed the majority of their movements in the narrow range of possibilities right after they had constructed an interaction model. Kocaballi (2013) noted that the participants preferred not to engage in a continuous negotiation process, and there was a tendency to stabilize the patterns of action. His findings suggest that, in addition to providing an open movement space, an explicit interest in destabilization and divergence might be required in order to support more variety in actions. The tendency toward stabilization and convergence puts forward questions. How, through time, are movement patterns settled and become inscriptions for future movements? How do self-defined inscriptions transform into collectively defined inscriptions? And, how is convergence prevented in the cases where continuing free exploratory movements are desired?

On the other end of the spectrum, there is a closed action space with many constraints on human movements. In closed action spaces, human actors perform their movements in accord with strong inscriptions. However, there may be cases in which strong inscriptions are not strong enough for all human actors. Actors may translate the available inscriptions in different ways or deliberately prefer to translate them differently, even though the inscriptions are considered strong. In other words, actors may not interpret the available constraints, restrictions,

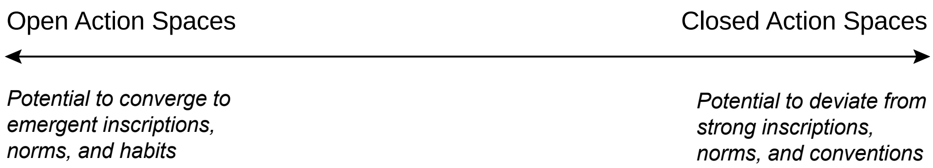

Figure 5. The spectrum of closed and open action spaces has potential for convergence to or deviation from varying types of inscriptions.

guides, or affordances in the intended ways or they may intentionally go against the scripted actions (Akrich, 1992). Deviations refer to those instances where human actors' actions deviate from the dominant scripted actions. It is important to note that deviations do not necessarily correspond to undesired instances. In the design literature, various approaches aim to utilize deviations as a way to empower users or the variety in their actions, such as designing for appropriation (Dix, 2007), designing for ambiguity (Gaver, Beaver, & Benford, 2003), staying open to interpretation (Sengers & Gaver, 2006), and seamful design (Chalmers & Galani, 2004).

Open and closed action spaces may help designers in understanding the enabling and constraining characteristics of human–technology relations on humans' movements. They can also be helpful in foreseeing deviations from the scripted movements or convergences to a limited set of movements. In general, although there may be deviations or convergences, open action spaces support more variety in movements while closed action spaces keep movements in a predictable range.

Transforming Inscriptions and Translations in Use

Having explained convergences and deviations in open and closed action spaces, we will now demonstrate how shifts across those spaces may take place by transforming eMoto's material and social inscriptions—through user appropriation or the creation of new technology-enabled social protocols. The current version of eMoto is deliberately designed to be open, flexible, and interpretative by its users so that they can develop the kinds of affective gestures most resonant with their individual preferences and personalities. The communication of emotional expression through the visual representations on the mobile device is also open to interpretation by the receiver of the message. Despite the designed-in or inscribed flexible interface, it may be the case that, over a period of extended use, a person develops a recognizable set of habitual affective gestures. That is, he/she tends to always perform the same kind of gesture for a specific emotion in a similar way. What was previously a weakly inscribed material influence on possible expressive movement behaviors has now become a strong bodily inscription. The person has incorporated a set of affective gestures into his/her bodily repertoire. The material inscription of the device has not actually changed—it was intended by the designers to be a weak inscription enabling flexible programs of action—but the practices of the human actor in appropriating the use of the device have translated the material inscriptions into a stable set of affective gestures, effectively becoming a strong choreographic inscription. In this case, a person's developing some habitual affective gestures over time changes the strength of inscriptions from weak to strong and transforms the action space from open to closed. As a result, a convergence to a limited set of gestures takes place.

In addition to developing habits, there can be other factors transforming the strength of inscriptions, such as continued exposure and the capacity of people to perceive inscriptions. Rico and Brewster (2010) maintained that humans' relationships with a device may create a new standard of social acceptability through continued exposure. Furthermore, the possession of a device may also allow a person to perform atypical gestures that are not normally socially acceptable in a particular setting because the person is perceived as a new hybrid actor, combining person and device. As the movement gestures are attributable to a person–device hybrid, the gestures may not be subject to the same social inscriptions[1] affecting a person without any devices. However, this would be the case only if the person believes that his/her device is perceivable by observers. Rico and Brewster (2010, p. 894) observed that it is "not the energy required to perform a gesture that makes it acceptable, but the perceived appearance of that gesture." Therefore an important factor for social inscriptions is the public availability or perceptibility of gestures.

From the perspective of design, social inscriptions may represent a challenge because designers have very little control over the unfolding of these inscriptions that may cause deviations from the intended human and device interactions. However, participatory design methods—such as workshops, enactments, and prototypes—may prove useful for identifying and accommodating the unexpected effects of social inscriptions. Although material inscriptions are generated in accord with social inscriptions, in some cases the former might be employed to subvert the latter. For example, Serendipitor (Shepard, 2010), a mobile phone app for walking through city streets in a dérive[2]-like fashion, employs strong inscriptions, such as well-defined explicit and disruptive instructions about what to do at each step of interaction, in order to allow the app users to break up their daily habitual movement paths and patterns.

Shifting Across Action Spaces by Design

In this section, we discuss how transforming material, social, and choreographic inscriptions by design may result in shifts across action spaces with different action possibilities. We return to Latour's example of the hotel manager and room key to illustrate how an inscription's power to achieve a desired action is transferred from a weak social inscription in the first option (oral communication) to a weak material inscription in the second option (a written notice) to a stronger form of material inscription in the third option (a heavy weight attached to keys). While the first and second options, with their weak social and material inscriptions, stay in the open action space in which the hotel customers do not leave the keys at the front desk as requested, the third option shifts to the semiopen space in which a strong inscription of an attached metal made the majority of customers leave their keys at the reception desk. Figure 6 illustrates this transformation process.

In order to demonstrate how similar shifts may take place in eMoto, we introduce three cases involving one original and two hypothetical versions of eMoto. Case 1 involves the original eMoto The Perfect Job scenario (eMoto V1) in the home; Case 2 involves a hypothetical redesign of eMoto (eMoto V2) used at home; and Case 3 involves another hypothetical redesign of eMoto (eMoto V3) employed in a public place.[3] Figure 7 illustrates the three cases.

Case 1 with eMoto V1 involves a typical user interaction of communicating the emotion of excitement by performing vigorous shaking of the device with the arm held up above the head (refer to Table 1). In this scenario the person is sitting at a desk; the desk is a material constraint resulting in restricted physical movements of the body. An alternative option is for the person to perform the affective gesture while standing, which may result in more spatially expansive body movements. The spatial shaping of the body is depicted in Figure 2(iv). When standing, the action may become more pronounced as the hips swing to counterbalance the swing of the arms. The weak material and social inscriptions are translated by the human actor in flexible ways, as intended by the designers.

The eMoto V2 in Case 2 aims to encourage larger body movements through changing how the sensor data are computationally processed, achieved technically through programming the accelerometer to require bigger spatial gestures to generate data. For example, the emotional

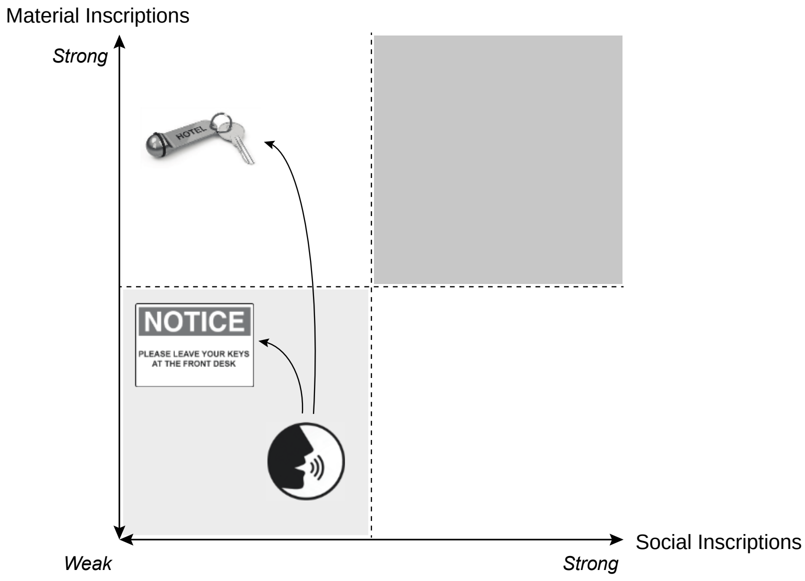

Figure 6. Transforming inscriptions for the case of the Hotel Manager: A weak material inscription of a written notice and a weak social inscription of an oral communication are transformed into a strong material inscription through the use of a heavy weight on the door key.

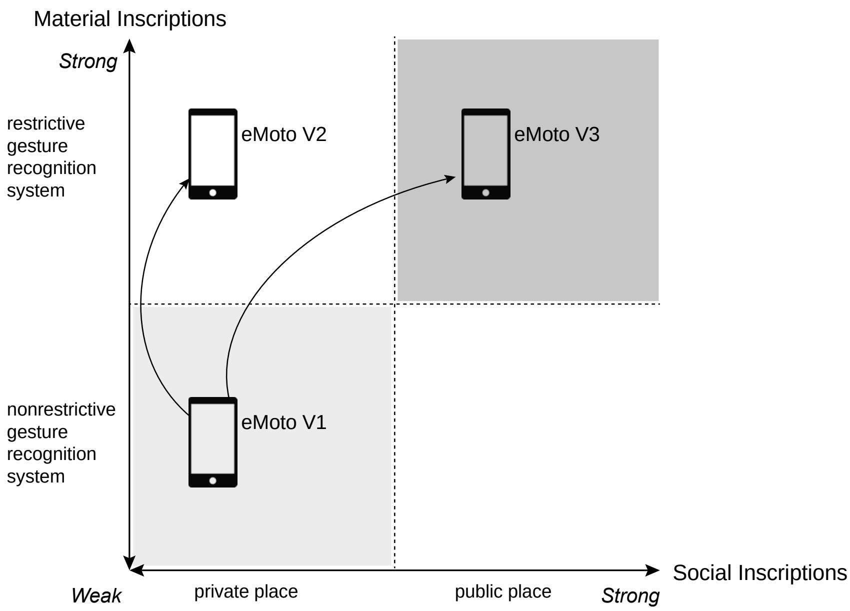

Figure 7. Transforming inscriptions for the three cases of eMoto: Version 1 has weak material and social inscriptions, transformed into a strong material inscription in Version 2, and strong material and social inscriptions in Version 3.

expression of excitement may require a more exuberant action, perhaps jumping up and down with the whole body with the arms also flapping up and down. In Laban terms, this action demands high effort, characterized crudely as elements of flick/slash for the arms/torso and thrust/press for the legs. The shape component of the action can be described in terms of quality—whole body expanding/contracting in the vertical/horizontal planes—and directional—up/out into space as the body expands and down/in as the body contracts, with the spatial intent more outward oriented and with less attention on the device stylus. This is an example of how a desired choreographic inscription is then translated into the material properties of the device. The introduction of strong material inscriptions (i.e., the requirement of amplified gestures) can move Case 2 into a semiopen action space in which the system ignores smaller movements and requires users to perform more exuberant movements in a more limited range.

The eMoto V3 in Case 3 provides an additional functionality to formalize a set of affective gestures for sharing among friends. Often couples or good friends develop their own idiosyncratic social language—a set of gestures with specific meanings mutually created, recognized, and performed only within that group. The eMoto system could be customized to enable the creation of a formal gestural vocabulary for sharing between select people. This new feature would be a strong material and choreographic inscription of preferred or desired affective gestural expressions, changing the original weak material inscription embodied in the eMoto system to a stronger one. This social agreement may give the users a sense of permission to flaunt acceptable social behaviors, especially in public settings, enabling a potentially greater range of physically expressive affective gestures than usual. This is an example of how a social inscription embodied in the social agreement between friends is translated into a material inscription by adding new functionality to an existing system that is then translated into actual user actions corresponding to their shared gesture set. Through the introduction of strong social (i.e., public place and social agreement between friends) and material inscriptions (i.e., a user-defined gesture recognition system), Case 3 can shift to a closed action space in which the majority of the users' gestures can be performed in accord with the predefined set of gestures, in other words, a strong choreographic inscription.

In summary, the combination of open/closed action spaces and weak/strong inscriptions can help designers to think through the relative merits of enabling or constraining programs of action in material, social, and choreographic terms. It is possible through intentional design acts to inscribe desired choreographic or social behaviors in the material properties of technologies. However the actual translation of material, social, and choreographic inscriptions in practice can result in convergence or deviation from the expected programs of actions. Whether the transformation of inscriptions and translations takes place in actual use through acts of user appropriation or by intentional design acts, the application of our framework can draw attention to how the strength of inscriptions and translations evolves over time to produce varying qualities of movement in open or closed action spaces.

IMPLICATIONS FOR THEORY

Our framework employs some core concepts from ANT and Laban's effort and shape to help recognize multiple sources of influence on humans' actions and movements. The framework can be expanded to include various other material and social inscriptions according to the level of relational sensitivity desired. There are two main implications for design theory. First, humans' actions and movement choreographies cannot be considered independent phenomena; they take place within a network of other human and nonhuman actors acting as multiple sources of influence, that is, inscriptions, on action possibilities. Second, the relations between inscriptions and actual actions and movements are semideterministic. Therefore, a strongly scripted choreography situated in a closed action space may not result in expected movements, whereas a choreography with weak scripts taking place in an open action space may not support sustained variety in movements. Although in practice it is not possible to consider an entire network of social and material inscriptions, developing sensitivity towards recognizing the multiplicity of inscriptions may prove useful for foreseeing possible cases of deviation from the desired flow of interaction and accommodating those deviations.

CONCLUSION

We have presented an analytic framework combining the notions of inscriptions and translations from ANT and a vocabulary for describing qualities of movement based on Laban effort and shape to draw attention to the range and quality of movement enabled or constrained by interaction with interactive technologies in social settings. The dimensions of material, social, and choreographic inscriptions characterize the framework. The power of the framework was demonstrated by applying it to the eMoto case study. This affective gesture system was selected to illustrate how different design or technology decisions can result in the inscription in bodies of different types and degrees of movement patterns and qualities, as well as the social factors influencing the performance of expressive movement behaviors.

The use of the ANT terms inscription and translation is critical for how we have defined the notion of choreographic inscriptions in this paper. They allow a balance between determinism and nondeterminism in the relations between humans and other entities and capture the ongoing processes of interpretation and appropriation involved in interactions between humans and interactive technologies. The actual movements performed in interaction can be thought of as a translation of both material and social inscriptions, resulting in a choreographic or movement inscription distributed across a network of people, artifacts, and protocols. The use of the Laban effort and shape descriptions of qualities of movement provides a language for partially articulating these choreographic inscriptions. Our aim is to provide designers with a language and vocabulary with which to reason about the qualities of movement in relation to technology design decisions and the social settings in which interaction with the technology takes place, not to prescribe or reduce the movements performed in actuality.

The framework contributes to the palette of tools available for sensitizing designers to the variety and qualities of movement that are enabled, constrained, or inhibited by technology design decisions. It is not limited to interactive technologies but can be applied more broadly to designed objects, structures, and systems. Furthermore, it is important to note that our framework does not suggest that designers should avoid constraining user behavior or should always support higher amounts of flexibility in technology use. Rather, our intention is to help designers to develop an account of enabling and constraining effects of design decisions, on the one hand, and the possibilities of deviations from the expected human–technology relations on the other. In future work, we wish to expand our analysis of the qualities of movement from the observational perspective taken in this paper to embrace the internal felt experience of movement. Rather than just designing for the outward form of movement, the notion of choreographic inscriptions can be extended to more fully consider the design of kinesthetic choreographies. That is, it may be desirable to foreground the kinesthetic experience of movement within our framework, to better support this dimension in the design of interactive technologies. We believe that the analytic framework presented in this paper can contribute to the growing awareness of the significance of human movement within discourses and practices of technology design, and in turn, encourage the design of an ecology of artifacts that embraces and promotes a fuller spectrum of movement where the quality of movement is recognized as critical for the quality and vitality of life.

ENDNOTES

1. Latour's (1999) discussion of a case involving a gun and a man provides an invaluable insight on the agency of human and nonhuman hybrid collectives.
2. The word *dérive* is French for drift and refers to the situationist practice of exploring urban environments through "playful-constructive behavior and awareness of psychogeographical effects" (Debord 1956/2006, p. 1).
3. It is important to note that the cases illustrate a simplified consideration of social and material inscriptions in demonstrating how shifts may take place between different spaces of possibilities. In praxis, many other factors may be influential on the movements observed.

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QUANTIFIED BODIES IN THE CHECKING LOOP: ANALYZING THE CHOREOGRAPHIES OF BIOMONITORING AND GENERATING BIG DATA

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Abstract: *Biomonitoring digital devices have become popular in physical activities and are receiving intensive focus as motivational and support vehicles for health. The aim of this article is to develop a new theoretical framework to analyze biomonitoring from the two perspectives constituting the opposite ends of the big data spectrum: individual (micro) and institutional (macro). In applying phenomenology of the body, discussions of choreography, and Latour's actor–network theory, I seek to evolve a choreography-based approach that can outline feedback systems between embodied practices and the macrolevel choreography of big data. Health informatics data as economic and political assets are illustrated based on netnography. Netnographic methodology pays close attention to online fieldwork and media texts. Emphasizing the lived body in the analysis of knowledge infrastructure, I aim to contribute to the theoretical discussion of human–data interaction. The findings suggest that highly intimate, personal technology can distance people from their lived bodies.*

Keywords: *biomonitoring, wearable technologies, choreography, phenomenology, embodiment, big data, human–data interaction.*

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INTRODUCTION

The interests of health policymakers and employers have increasingly become involved with self-care interventions, such as healthy diets and physical exercise, to provide health benefits for people and reduce health-care costs. The use of self-monitoring digital equipment in physical exercise, likewise, is becoming increasingly popular and receiving more and more attention as a motivator and support vehicle for self-care and well-being. Self-monitoring, or biomonitoring, refers to tools such as wearable electronic sensors and mobile phones with apps that collect, store, process, and display data about bodily functions. Also known as self-tracking, self-quantification, or the quantified self, biomonitoring has flourished within the domain of health and physical exercise, where a strong demand from competitive sports and biomedical technology resulted in the commercialization of consumer health devices. Compared with a simple pedometer that counts each step and shows the overall figures to its user, the new generation of fitness tracker devices—like the Fitbit, Jawbone Up, and, more recently, Apple's iWatch—are small computers that also can collect, generate, and share data about the physical body. With this information, individuals can manage multiple aspects of their personal health informatics.

The designers of fitness trackers (see, e.g., Medynskiy & Mynatt, 2010) emphasize that biomonitoring is intended to motivate persons to achieve healthy lifestyles. Some fitness trackers are aimed towards full-day activity monitoring, while others focus on single workout monitoring. Users employ biomonitoring technology in different roles within their lives. The design of personal health informatics devices is grounded on the belief that such systems can, through the collection and presentation of personal information, promote individuals' self-awareness and that improved self-awareness consequently leads to self-insight, self-control, and positive, healthy behavioral change (e.g., Khovanskaya, Adams, Baumer, Voida, & Gay, 2013). The quantified self (QS) movement is a network of people whose aim is to promote self-monitoring activities by acquiring data on various aspects of users' physical bodies to improve personal health or professional productivity (Quantified Self Labs, 2015).

By examining biomonitoring through the lens of phenomenology, I propose to rethink self-tracking data production and its rationalities. The fundamental aim of phenomenological philosophy is to develop a greater understanding of individuals' experiences through the consciousness of the experiencer (Giorgi, 2009). The phenomenological approach, as used here, is based on a phenomenological notion of the body, more specifically the distinction between the physical body, or *Körper*, and the lived body, or *Leib* (Husserl, 1954/1970; Leder, 1990, 1998). The primacy of *Körper* has been highlighted in many disciplines, including biomedical technology, and in diverse aspects of sport sciences, physical education, and human–computer interaction (HCI). In the everyday discourse of physical exercise, the body usually concerns *Körper*, a corporeal entity that consists of muscular fibers, complex brainwaves, neural pathways, circulation, and so on. In many popular fitness-training programs, people are expected to modify the *Körper* by building muscle, burning fat and calories, stretching muscles and tendons, and improving cardiovascular functioning.

In trying to provide an alternative to mind–body dualism, phenomenologists (see, e.g., Gallagher & Zahavi, 2012; Parviainen, 2011) outline the third category between body and the mind, the *Leib,* as a conscious, active, reflexive, and embodied entity. Following Husserl's notion of *Leib*, Merleau-Ponty (1945/1962, p. 139) described the lived body, *corps vécu*, as a conscious subject that is never a mere physical thing but has its own intentionality and body awareness. Merleau-Ponty (1945/1962) and Sheets-Johnstone (1999) have stressed that bodily sensations, in particular tactile and kinesthetic sensations, may have clear meanings without overt symbolic (linguistic) value. The sense making of bodily movements does not reside in words but is evoked in the meeting of the spatial and material world and other living beings.

Today's biosensors can provide robust data about physical bodies, such as pulse, step count, blood pressure, and so on. By collecting and processing data based on software, some biosensors also provide verbal or textual signals to users, such as, "exercise harder" or "drink water." However, people can experience a range of vague bodily feelings and sensations that they cannot monitor. For instance, individuals cannot expect to receive a diagnosis of the feeling of resonating with other lived bodies in everyday life, no matter how well the sensors work; making sense of their vague bodily feelings during exercise poses problems that go beyond reading signals from biosensors. The phenomenological approach of this study aims at making sense of how biomonitoring equipment collects physical data from physical bodies but cannot reach lived bodies, the bodily sensations, feelings, kinesthesia, affects, atmospheres, and desires in and between bodies.

However, despite its clear assets as a method, phenomenology sometimes fails to address the social context of lived experiences (Langridge & Ahern, 2003). Furthermore, although phenomenology can help generate structures of lived experiences, it is not suitable for making generalizations about institutional structures (Mayoh & Onwuegbuzie, 2015). As Savat (2013) suggested, technological ensembles now take place on a greater scale than they ever did before. To meet the aims within the broader theoretical framework of HCI, actor–network theory (ANT; e.g., Latour, 1997) and theoretical discussions of choreography (e.g., Schiller & Rubidge, 2014) are brought together to highlight the role of movement in biomonitoring. One of the greatest strengths of phenomenological methodology is its flexibility and adaptability that allow for its incorporation within other disciplines (e.g., Dourish, 2001; Garza, 2007).

Given the rise of social networking and mobile technologies—and the ever-increasing digitalization of leisure and daily actions, including fitness activity—the quantity of personal data being generated today has reached an unprecedented scale. Big data is considered here primarily as a knowledge infrastructure generated through an ensemble of techniques (Ajana, 2015). When a society is becoming data-driven (Pentland, 2013), it is important to make distinctions regarding how personal data are created. Observed data, such as online shopping behavior, are inferred and created from information about individuals collected by programs (Mortier, Haddadi, Henderson, McAuley & Crowcroft, 2015; World Economic Forum, 2011). Data can be intentionally created by individuals through online social network profiles, which is a process called volunteered data. Personal data created by wearables are observed data but people usually provide it through online social network profiles, so it becomes volunteered data.

To describe this data collection and its political and economic implications, an ethno-methodological approach or, being more specific, a "netnographic" approach, was used in this study. As a modification of the term ethnography, netnography refers to online fieldwork that follows from the conception of ethnography as an adaptable method (Kozinets, 2010). The Internet has become an important site for research, so a number of researchers have utilized online communities—including newsgroups, weblogs, forums, and social networking websites—to examine various phenomena. Recent media texts, such as newspaper items, columns, and blogs, are used to illustrate how personal health informatics is collected through sensors and trackers to generate big data.

When individuals are bound through their digital devices to processes in which their personal data are collected, analyzed, and traded, it is necessary to reflect on the feedback mechanism of this system. HCI research has traditionally focused on the interactions between humans and computers-as-artifacts. However, Elmqvist (2011) and Haddadi, Mortier, McAuley and Crowcroft (2013) suggested that it is time to recognize the phenomenon of human–data interaction (HDI). HDI does not concern interaction between humans and computers generally but, rather, between humans and the analysis of large, rich personal datasets. As Haddadi and his fellows (2013, p. 5) stated, "HDI overlaps HCI but is not contained within it." HDI concerns people interacting with an apparently mundane knowledge infrastructure that they do not necessarily recognize or understand or would rather ignore. Opening up such infrastructure and its dynamics is a challenge because the scale of these systems is much bigger than usually considered in interactional studies.

To understand the dynamism of how information is generated, two perspectives are important: the individual (micro) and the infrastructural or institutional (macro). As Klauser and Albrechtstlund (2014) suggested, these constitute the opposite ends of the big data spectrum. These opposites are not combined in an arbitrary manner but include complex feedback systems. In the endeavor to study the intimacy inherent in everyday use of wearable computers combined with big data development, the notion of choreography, Latour's notion of ANT, and the phenomenology of the body help to develop a coherent theoretical framework. The notion of choreography and its related concepts, such as kinesthesia and kinesphere, assist in capturing an intimate integration of everyday use of wearable sensors and lived bodies.

In this paper, my aim is to develop a new choreography-based theoretical framework to analyze biomonitoring on a larger scale, instead of as a mere personal activity. The notion of HDI (Haddadi et al., 2013) assists discussions of human–technology choreographies to consider what kind of feedback systems link the microlevel choreographies of personal biomonitoring to the macrolevel choreography of collecting big data. This paper begins, firstly, with how the processes of collecting personal data as health informatics are illustrated based on a netnographic methodology. Secondly, choreography as a theoretical framework is introduced to show how it assists in analyzing biomonitoring in everyday life. Next, particular attention has been focused on the phenomenological view of embodiment to show why individuals cannot reach the lived body through fitness trackers. After, my aim is to outline how a "checking loop," such as a microlevel choreography, has become normalized as an embodied practice in the context of fitness and well-being. The paper concludes by discussing feedback systems that turn the macrolevel choreography of generating big data back toward citizens and consumers to establish new types of embodied disciplines and health care policies.

BIOMONITORING AND PERSONAL HEALTH INFORMATICS

Personal health informatics data, which have emerged only in recent years, represent an entirely new class of data. They refer to self-collected intimate data about one's own health and health-related activities, often obtained autonomously from smartphones, activity trackers, wearable devices, and other sensors. Self-tracking applications can collect all kinds of everyday activities, thoughts, and statuses into discrete data that can be stored, analyzed, and used to guide to positive outcomes. They are quantifiable, analytical data about health, habits, and routines, from the temperature in a particular sleep environment to the exact amount of time people have been still, sitting in a chair (e.g., Li, Dey, & Forlizzi, 2011; Thomaz, 2013). An increasing number of people are carrying smartphones and devices with them all day, every day, and these devices can be used to collect data.

Most modern smartphones have a plethora of sensors built into them and many of these have self-tracking applications. Smartphones are primarily telephony devices, but the inclusion of multiple sensors along with a suitable app execution environment can turn them into general purpose, self-tracking devices. The sensors of smartphones may include an accelerometer, gyroscope, barometer, heart rate sensor, thermometer, proximity meter, and navigation systems (Barcena, Wueest, & Lau, 2014). Apps also assist users in collecting data from the physical body that sensors currently cannot capture, such as data on moods, food and drink consumption, aches and pains, and so on. In addition to smart phones, fitness trackers like Fitbit, Jawbone UP, and Lullaby sense many types of human activities and dissect these activities into quantified measures, such as the number of hours in REM sleep.

In monitoring physiological measurements, such as pulse, respiration, and blood pressure in terms of fitness activities, fitness trackers do not just give feedback to the mover, but they also can allow data to be collected and processed based on proprietary software and algorithms. Wearable devices typically have a small and light form factor, letting users wear them on the wrist like a wristband or as a watch. Alternatively, they can be attached to sports equipment such as running shoes, clothes, bikes, and more. These devices usually contain accelerometers and gyroscopic sensors that are responsible for generating the data. Barcena and his fellows (2014, p. 12) stated that, “By reading the stream of data from these sensors and then applying data processing algorithms, the devices can recognize patterns to identify the wearer’s current activity.” To indicate how many calories the user has burned, for example, a tracker needs to access data on the user’s age, gender, height, and weight and add them to data about the user’s heart rate, estimation of perspiration, and how many steps have been taken, and then ultimately process all this data to generate the single measure based on its algorithm. To translate the raw data into actual figures and statistics on their screens, fitness trackers use slightly different algorithms.

As Thomaz (2013, p. 3) suggested, before fitness trackers and wearables emerged, “We were not conscious of how many flights of stairs we climbed on a given day or the exact amount of time spent brushing our teeth.” Therefore, from the perspective of phenomenology, it is clear that these systems are actually tracking tacit bodily activities and make these trivial routines more visible in daily life. In fact, biomonitoring quantifies a dimension of physical bodies of which people were not aware and considered as irrelevant information. This stream of data is of interest now because people have collectively understood that these previously ignored quantifiable dimensions implicate their state of health and well-being to the extent that they should attend to them. In effect, data collecting by biosensors constitutes the foundation of many health-related activities and behaviors.

Recently launched fitness tracker devices, such as Apple’s iWatch, are already preparing to play a bigger role in collecting health informatics from their users. Smart fabrics and materials, smaller sensors and processors, and improved battery life within the ubiquitous communications infrastructure have all opened up a new world of possibilities for devices that can be worn and carried around all day. Microsoft and Apple are in competition to develop a smart watch that includes glucose-monitoring technology. Olson (2014, p. 1) pointed out that, glucose monitoring is the holy grail because of the insights that could give into what someone has eaten. That would be a crucial data point for insurers because diet has a far greater impact on health than activity.

Typically, persons who are actively tracking their bodies are sports enthusiasts. Using sensors, keen runners can collect data about their running activity to help them set performance goals and evaluate their progress. Being constantly logged in to their performance data, they can witness their dynamic physical condition and choose a proper technique to improve their results. Moreover, as Barcena and his fellows (2014, p. 6) stated, “There are also self-tracking geeks who are interested in documenting all facets of their daily lives in as much detail as possible in public and have turned the whole idea into an art form.” Aside from enthusiast users, many people may be just curious or wish to achieve a goal, such as losing weight, getting more sleep, or living a generally healthier lifestyle. While the health benefits of use of self-tracking devices and apps cannot be scientifically proven, many people clearly believe they are beneficial for their motivation. Biomonitoring and personal informatics are perceived largely as a positive development because they offer people the opportunity to gain a more refined understanding of their physical body’s condition. Nevertheless, it is still important to remain critical and examine the extent to which the practice might affect their lives.

Self-tracking is already a big business and is expected to grow rapidly. According to PricewaterhouseCooper’s (2014) report, 1 in 5 Americans owns some type of wearable technology. This figure does not include smartphones that can run self-tracking apps that would, if accounted for, amount to billions of units worldwide. According to a study by Fox and Duggan (2013), 69% of Americans regularly track their weight, diet, or exercise activity. One key technology driver behind big data is the potential of the wholesale of personal data (Barcena, et al., 2014). For instance, insurance companies are interested in gaining access to data generated by fitness trackers (Accenture, 2015) because big data would be extremely valuable for risk estimations.

Never before have such huge amounts of health informatics been collected, transmitted, and stored about users. So the question of anonymity of data has become more relevant. The anonymity of data collection can be at risk when data are being sent from one device or location to another. One concern is that users are tracked without knowing other devices nearby are collecting information on them. Although some of the data could be considered highly sensitive, much of the information listed is not. For example, hospitals are required to carefully handle medical data, but data about the amount of water a person drinks daily are not seen as delicate information. Gaining access to personal health data is a potential goldmine for employers because these data can allow them to gain deep insight into their employees. Olson (2014, p. 1) suggested that “more employers are opting to monitor data being generated by fitness trackers—to the extent they can see it on a dashboard—and are holding their insured staff to account with rewards as part of a growing number of so-called corporate-wellness programs.” Employers are exploring ways to monitor their staff's wearable devices to help them reduce health-care costs. As part of corporate wellness programs, employers may offer their employees fitness trackers and, as a service for monitoring this data, they might reward employees for fitness activity. To explore further why personal data are not a mere personal issue, I consider in what kind of theoretical framework biomonitoring can be analyzed on a larger scale without losing touch with its intimate act.

CHOREOGRAPHY AS THEORY

Choreography can be divided into practice and theory. Plenty of guidebooks for dance students and other practitioners present how to make choreographies in practice (e.g., Blom & Chaplin, 1989; Smith-Autard, 1996; Tufnell & Crickmay, 1993). Then there is research literature that develops theoretical and philosophical approaches to choreography, mainly in the contexts of dance cultures and performance (e.g., Kozel, 2007; Lepecki, 2006; Manning, 2009). The line between practice and theory blurs, however, because movement theories usually emerge from practical knowledge and experience, involving a hermeneutic circle between theorizing and practicing. Rudolf Laban was a good example of a choreographer who also developed a movement theory and movement analysis method. Laban's effort–shape (1980) is a widely used method to analyze everyday bodily movements in different contexts, including HCI (e.g., Hummels, Overbeeke, & Klooster, 2007; Loke, Larssen, Robertson, & Edwards, 2007). However, as a movement theory, effort–shape has some limitations in the context of this study. Laban restrained the analysis of movements and gestures in a limited space and time scope so, as a theory of choreography, it is not necessarily the best approach to analyze movements whose scale can reach across the world. In addition, he did not give much weight to nonhuman agents and environments in making movements.

My interest in this paper is to consider movement as a relational net or a reciprocal and dynamic matrix. The choreography is manifested and materialized by bodies, action, and environment rather than simply bodies making movements to create choreography. There is a reasonable amount of theoretical discussion of choreography (e.g., Butterworth & Wildschut, 2009; Foster, 1995; Hunter 2015; Klien, 2007; Parviainen, 2010; Robertson, Lycouris, & Johson, 2007; Schiller & Rubidge, 2014) that can assist in developing a coherent choreographic approach to understanding movement in the context of this study. I wish to (a) consider constellations of movements in which various actors/agents are involved and (b) disrupt notions of inside versus outside the body. In this context, choreography is not seen as belonging to the domain of dance. Rather, choreography refers to movements and activities in which movements appear to form meaningful interactions and relations in a lived space between various animate or inanimate agents. Thus, no choreographer alone could lead the dynamics of this constellation; rather, human and nonhuman agents have connections with each other that establish ongoing choreography. Treating human and nonhuman agents symmetrically here, choreography is seen to arise from their relations that become perceptible through movements, motion, patterns, and rhythms.

This notion of choreography resonates with theories of the actor network (e.g., Latour, 1997; Law, 1992). Latour (1997) and his colleagues (e.g., Law, 1992) suggested that objects can become agents or *actants* with humans, influencing action as well as resulting from it. An assemblage of people, objects, and technologies are composed of heterogeneous elements that enter into relations with one another. When digital technologies, action, and materiality intertwine, human bodies do not remain independent entities from technologies. In this assemblage, embodied connections with digital technologies modify physical and lived bodies, forming new kinds of *embodied practices*. Deborah Lupton (2013, p. 400), alluding to Peter Freund, used the term "technological habitus" to describe how bodies develop new habits and routines to blend in with the function of technologies. She suggested that bodies do not intermesh smoothly or seamlessly within technology but rather there are disjunctions between bodies and objects. Embodied practices do not refer to mere habituation or the domestication of technology but to how new bodily activities are developed to cope with or utilize new technologies. For instance, running as a form of physical activity is not dependent on any high-tech gadgets. But, running with sensors and wearables depends on an assemblage of fitness trackers, apps, and perhaps link stations in the running environment. Although running with wearables mobilizes a new type of assemblage, it also changes the style of running when runners need to check certain numbers and figures on their wristbands to adjust their running speed. In this relational materialism, actants are managed to make new relationships and form new running routines as embodied practices.

Latour's (1997) approach to ANT emphasized agency and an assemblage of actors in which he did not give much concern to experiential aspects of these actants; in other words, how feelings, affects, and sensations influence relations among actants. The choreographic and phenomenological approach is to focus on the quality of action: How does the special quality of actants' movement keep action alive and make things happen? To answer to this question, it is important to rethink the meaning of movement and kinesthesia (e.g., Husserl, 1973/1997; Sheets-Johnstone, 1999) in an assemblage of people, objects, and technologies. It is necessary to consider what kind of role movement and lived bodies have in making affective relationships when pulling and pushing things towards a constellation. This notion of choreography challenges the traditional view of technology as residing in individual cognitive or psychological processes and instead shifts the focus of HCI toward embodied social activities and transitions in a network of heterogeneous elements. This choreographic approach recognizes the importance of the interaction of hardware and software technologies, bodies, and environments brought together in an active relationship and in a particular spatial configuration that can be both planned and improvised.

Kinesthesia plays a central role here in understanding interaction among lived bodies and their interactions within material environments. As a sense of motion, kinesthesia is something that helps researchers recognizes differences and similarities within a person's own movement qualities, haptic sensations, and the moving objects around them. When one lifts an object, this reveals something about the object's weight. Rubbing ones fingers across an object reveals details about the texture and shape of the object. Squeezing an object says something about its compressibility. Thus, bodily movements are fundamentally intentional and mindful in themselves in a way that they have a special kind of reflective thinking (Sheets-Johnstone, 1999). However, in the present study, the dynamics of interaction among bodies reach beyond immanent bodily experiences and kinesthetic limits.

In my previous studies with colleagues (Parviainen, Tuuri, & Pirhonen, 2013), we developed a notion of choreography that can help to evolve a coherent theoretical framework in which the emphasis is on the intimate physical contact of sensors combined with big data generated. We distinguished three scopes of choreography by using the terms micro-, local-, and macro-levels. In a *microlevel* analysis, the focus is on, for instance, the movement of the index finger swiping across the screen. These are the movements that take place within one's kinesphere or internally. *Local-level* choreographies refer to bodies in their social interaction, for instance, when passengers, sitting or standing on the metro, hide behind their phones in trying to avoid eye contact with other people. The *macrolevel* choreography refers to large-scale movements that go beyond human embodied efforts, for instance, to link transporting infrastructures or the Internet to create extensive trajectories. Thus, those passengers on the metro, hiding behind their mobiles, might read text messages from their friends on other continents or watch a video on YouTube that has been seen by over 100 million other people.

Instead of focusing on material objects and singular gestures in using them, this choreographic approach offers a new theory to consider movements as trajectories, transitions, and relations in interaction design. This approach does not restrain the analysis of movements and gestures in a limited space/time scope but takes into account the scale of the three levels of choreography that are usually involved when people use digital devices in everyday life.

Before I consider further the idea of choreography in the context of biomonitoring and fitness trackers, the notion of *innesphere* is introduced to illuminate the difference between the lived body and the physical body.

INNESPHERE AND THE LIVED BODY

Turning back to Laban (1966, p. 10), he created the concept of *kinesphere* that was defined as the "space which can be reached by easily extended limbs." By kinesphere, Laban referred to bodily movements and activities in an "individual bubble." Drawing on the sociological discussions of personal space (Moore & Yamamoto, 1988) and the phenomenological notion of subjective space, the concept of kinesphere can be also understood to include affective and social connotations forming lived space. The spatiality that individuals live in and through their bodies and that surrounds them is called lived space, and it plays a central role in local-level choreographies. Phenomenologists (e.g., Husserl, 1973/1997; Merleau-Ponty, 1945/1962) considered that the lived body cannot be treated as a mere material object that locates in the three-dimensional geometric space. In this sense, the notion of lived space differs from the schema of Euclidean three-dimensional space or a mere individual bubble. Objective space can be scrutinized and measured with fixed metrics, and it has become the foundation of the physical sciences and digital technology.

To understand human movement in all its complexity, it is not enough to focus on physical bodily motion within the kinesphere but also to the inner movements of the body. If the kinesphere is the lived space that can be reached easily by extended limbs, *innesphere* concerns the internal space that can be reached under the skin. The skin should not be understood as a boundary between the kinesphere and the innesphere but rather as an interface that binds together inner bodily feelings and outer perception. The term "body image" aims to capture the internal and intimate feelings of one's own body, but it emphasizes too much the visual and psychological aspects of embodiment. The notions of "body awareness" (Mehling et al., 2011) or "body topology" (Foster, 1997) are more helpful in understanding what is meant here by the dynamics of innesphere as a lived space. Body topography emphasizes the spatial character of the body as a lived space that describes internally felt body parts and spots and relations as a moving structure. Thus, movements within the body topography and innesphere do not just simply refer to bodily functions such as heartbeats or breathing, but how we *feel* them. Individuals usually locate the feeling of pain somewhere in their body topography, identifying its sensuous dynamism with terms like sharp, sore, itchy, stabbing, burning, stiff, stinging, tender, thumping, or tight. Feeling bodily sensations, as examples of movements within the innesphere, can also be imaginary and socially loaded. If meaning movements within the body topography can be imaginary or partly culturally constructed, then wearable technologies can hardly track them.

Therefore, wearable technologies cannot track sensations, feelings, and movements within the body topography in a manner that makes immediate sense and intuitive understanding.

Wearables and sensors track functions of the physical body, such as pulse, steps taken, or blood pressure, and turn these data into numerical or graphic forms based on their algorithms. So, what people are actually doing is reading on the screen the numerical data of their body functions but not really feeling their movements and sensations. Thus, these devices cannot capture the sensuous feelings of the lived body and its dynamics in the innesphere. Next, this analysis moves on to consider how the notion of choreography can assist in examining the movements of biomonitoring. The aim is to describe how biomonitoring takes place within one's kinesphere as a microlevel choreography.

CHECKING LOOP AS MICROLEVEL CHOREOGRAPHY

In self-tracking physical performance, people usually glance at the device's display from time to time to check on the data on body functions. Nagamura (2015) suggested that the action of looking at a mobile phone display has become increasingly universal. Users may look at their mobile phone displays with strong intent even when this action is nonessential. Research has indicated that some users intentionally look at their mobile phone displays to avoid unwanted conversation or hide themselves behind devices in public places (see, e.g., Baron & Campbell, 2012; de Souza e Silva & Frith, 2012). Nagamura (2015) argued that the action of looking at a mobile phone display as a social gesture should be regarded as performative behavior. Whether looking at a mobile phone display is an intentional or unintentional gesture, this simple action can be also considered as a kind of microlevel choreography.

In the act of looking at a mobile phone display, as a microlevel choreography, the user's movement is restricted in turning the head and eyes towards the screen. Typically, this choreography consists of sequences of checking received messages or other information on the mobile. These checking sequences can be short or long, depending on how often the user handles his or her phone. The action of looking at a mobile phone display can become a harmful and compulsive behavior for users when it starts disturbing their essential daily activities (Roberts, Yaya, Honore, & Manolis, 2014).

As Nagamura (2015) stated, the mobile phone is considered an insensitive and forcible media because, even without any external calling, it keeps the user in a checking loop. Similarly, in terms of wearable technologies, users, such as runners, tend to look at these displays to check the informatics about their physical condition. In terms of fitness trackers, this choreography consists of sequences of checking informatics to which runners can respond by their physical activities, such as slowing down or speeding up, in following their fitness program in the correct way. This microlevel choreography might limit social interactions with other people in that the checking loop holds runners within their own private bubbles. Even if they might be running with others and transiting between places, they are concentrating on their own performance and controlling it within the checking loop.

Of course, the design of tracking devices is intended to provide information without being overly disruptive to the user. Users need only to glance quickly at their heart rate during their exercise. However, the data of biosensors orient the intentions of users during their workout. In monitoring the data, users actually ignore or bracket their feelings and sensations on body topography and other people within their kinesphere while concentrating strictly on the informatics of the physical body and its conditions. In this sense, the body is totally reduced to the numerical and graphic informatics on the display. The success of QS movement shows that monitoring the data of the pure physical body and its conditions frames people's everyday activities in a new manner. To reach the limit of 10,000 steps per day, people sometimes walk in place during their favorite television show. Nutrition blogger Scott Mowbray (2013) stated that, as soon as he puts his UP band on, he becomes, as he titled a blog post, "obsessed with walking 10,000 steps a day." He described how his tracker made him a "puppy," a "baby," or a "Boy Scout" when it comes to its feedback and control system. Even if most people see this as a positive development in motivating them toward a daily workout, trackers more or less keep them in a technological loop. In this sense, numerical and graphic data play a central role in what kind of interactions with digital devices people consider meaningful, motivating, and immersive during physical exercise. To understand both perspectives of biomonitoring—individual (micro) and infrastructural (macro)—I proceed to discuss how big data constitutes the opposite end of this feedback system.

BIG DATA AND MACROLEVEL CHOREOGRAPHY

Big data is often defined as data sets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyze (Manyika et al., 2011). In 2011, that amount of data was produced every 2 days; by 2013, that much was generated every 10 minutes (Ajana, 2015). Although emphasis is often placed on the size aspect, it is worth recognizing that big data is by no means solely about large data sets. In fact, big data is, above all, networked relational data (Ajana, 2015; Manovich, 2012). The size is certainly an important characteristic on its own, but the power of connecting, creating, and/or unlocking patterns, as well as visualizing relations, is what makes big data such a seductive field for investment.

In using wearable devices, individuals and their physical bodies are measured by proprietary algorithms that track various aspects of their actions and movements. Wearable devices not only track and collect data on customers but more and more guide and influence customers' activities, such as fitness routines, sleep patterns, and food consumption. When biosensors monitor how long an individual has been immobile, the apps installed on the device may encourage him/her to walk around at specified intervals. Or when a person is walking along the street, the device can provide automated "fitness nudges," such as stating, "You're near the park. Why not go for a run?" This also implies that embodied agency and free will become increasingly mediated by algorithms in a manner where actions are no longer intentional. As wearable devices reshape perceptions of the body and of movement, the way people act in the world becomes increasingly shaped by the algorithms that govern those devices (Budish, 2015). The more seamless the experiences with wearables individuals have and the more they rely on them to interpret their bodies, the harder it is to know when those devices do not work as intended.

Companies and governments often promote the illusion that algorithmic processes and data-driven systems have been purged of human bias, errors, and interference, leading to more neutral, objective, and automated decisions (Ajana, 2015; Muller, 2004). However, classification systems are neither neutral nor objective but are biased toward their purposes. According to Dwork and Mulligan (2013), the level of big data brings ubiquitous classification that demands greater attention to the values embedded and reflected in the classifications and roles these classifications play in shaping public and private life. Data collected through devices can be saved and later analyzed, opening up the potential for profiling and surveillance.

Nissenbaum (2009) highlighted that understanding privacy violations is often linked to who has power in the relationship and who is benefiting from an arrangement. Activity trackers and wearables are seen as powerful self-motivational tools, but what if they become mandated by employers to reduce sick days? As Olson (2014) pointed out, some employers have considered punishments for unhealthy behavior recorded by wearables. For example, the data used by an individual to meet personal goals and shared with health care providers to provide a more accurate diagnosis can also be shared with insurance companies to help maximize profits. Many of the privacy issues with wearables indicate that the data gathered by wearables may not be securely stored. Moreover, there are some indications that the current generation of models in this industry has not been designed with security as a priority. A recently released report noted that applications related to the QS frequently have not implemented even basic data encryption (Barcena et al., 2014.)

Very often, big data is seen as immaterial or disembodied, as separated from the physical bodies (*Körper*) and lived bodies (*Leib*). The danger in these perceptions is that such attitudes underestimate political and ethical consequences when addressing the implications of big data on identity, embodiment, and agency. To understand the dynamic among big data, the algorithms of sensors, and embodiment, it is necessary to turn again to the notion of choreography. In terms of wearable devices, microlevel choreography consists of the sequences of checking informatics to which users respond by their physical activities, to follow their fitness program in more or less obedient manners. In the checking loop of microlevel choreography, users generate not only data about the condition of their physical bodies but also about their intentions to follow, or not, the guidance and suggestions of fitness trackers. Even if fitness trackers and wearables cannot monitor the feelings of lived bodies, there are apps, such as MoodTracker, that persuade people to estimate and state their own feelings, moods, and emotions during and after their physical exercise. Manufacturers are interested in designing wearable devices that are more immersive and more pervasive in data collection. Big data is needed to develop further the algorithms for devices that can give more sophisticated suggestions for customers (Harwood, 2014). As the algorithms of wearables continue to advance, they become more adept at recognizing individual and collective patterns of behavior and, as a result, become more seamless extensions of the users' bodies (Charara, 2015).

As stated above in terms of HDI, people interact regularly with mundane and embodied knowledge infrastructures that they do not necessarily understand or even recognize. In this infrastructure, digital technologies, action, and materiality intertwine; bodies become actants of larger assemblage technologies and objects. Latour (1997) suggested that bodies do not just participate in these networks, but bodies are actively shaped by them, developing new habituation and embodied practices. A checking loop as a microlevel choreography can be considered an embodied practice that stabilizes and reproduces a network of biomonitoring while assisting the circulation of personal data. Personal information generated from individual microlevel choreographies constitutes big data as an opposite end of this process. These two opposites are not combined together in an arbitrary manner, but they include complex feedback systems. Even if the feedback system—from big data back towards individuals—can remain obscure and is delayed, it does not mean that feedback would not exist. The feedback system can be seen, for instance, in the manners of how employers first motivate and then later push employees to use fitness trackers to reduce their health care costs. Latour's vision can assist in understanding the feedback system as a network or as choreography rather than a simple mechanistic input–output system. Following Wittgenstein's metaphor, Latour (1997) recommended considering how a rope is made of many strings; numerous weak and short strings are intertwined together to form one strong rope. Moreover, it is not necessary that one string serves as the core throughout the rope's entire length. Translating that point into the case of embodied practices, when more and more people are involved in the checking loop as part of their everyday microchoreography, it becomes gradually a commonplace behavior that turns into a powerful norm to follow.

In this sense, moving bodies, monitoring their health informatics on the screen, can be seen to be involved in a much bigger loop beyond just a simple, personal, and intimate checking loop. This big loop concerns feedback systems that are built from the big data of health informatics and sent back towards customers. For instance, as Thomaz (2013, p. 3) suspected, "This emerging type of self-tracking data has become the basis of a participatory health movement where the axis of responsibility in healthcare shifts more towards individuals and away from institutions." This implies that people should take a much larger responsibility for their own health (Lupton, 2013). In this new landscape, self-tracking would become the norm, and people would be responsible for monitoring any symptoms of diabetes or cancer in their physical bodies. These types of reward-and-sanction systems can be developed to sustain the self-governance of individuals. Constructing profiles of individuals and groups in terms of their physical conditions could be used intentionally to diminish a person's range of future options and to allow or disallow a person to act in a certain way (Kerr & Earle, 2013). These feedback systems in biomonitoring from big data back towards individuals have only started to emerge, so it is still too early to speculate what kind of new norms and embodied practices this choreography can evolve toward in the near future.

DISCUSSION

The number of people adhering to biomonitoring and self-tracking is growing very quickly. If a mainstream participatory medicine movement materializes, as Lupton (2013) and Thomaz (2013) proposed, certain societal, health-focused expectations and behavior patterns with regards to self-tracking will be established. Self-tracking data bring to the foreground a new level of quantifiable health parameters that, in the long-run, could become new sources of health routines. These transformative patterns and expectations could be liberating, but they also might result in undesirable outcomes. In this paper, my aim has been to show that a choreography-based approach to biomonitoring can open up a new proactive perspective to understand feedback systems from the stream of big data towards everyday individual behavior. In this way, this chosen approach can make more visible how individual adaptions of new technologies entwine with the institutional level to affect the policy of health care systems in the long-run.

It seems, paradoxically, that the more individuals pursue goals of subjective choices, such as biomonitoring, the more frantically they build a world in which the means and ends are dislocated, resulting in a circular dynamic that only accelerates the processes of technological proliferation (Davison, 2004). I reiterate here that if analysis remains focused only on the microlevel dimensions of embodied experiences, it fails to cover the political and economic consequences of technological ensembles and their functions. To avoid the collapse of discussion about HCI into approaches that emphasize embodied cognition and subjective experiences, this choreographic methodology aims at illuminating intimate embodied experiences in the context of a large-scale data-processing system with political and economic interests behind it.

The analysis presented in this paper has shown how a microchoreography model of a checking loop can actually reduce individuals' chances of getting involved with instant experiences of lived bodies and social interaction with other lived bodies. One important aspect of biomonitoring as an everyday activity is that it brings forth an entirely new type of "instrumentalization" towards embodiment. The instrumentalization of the body refers to how people treat their bodies as external "test objects" by conducting various types of experiments as part of QS projects. This may lead to many difficulties, some of which have already been discussed in the literature (e.g., Kaptelinin & Nardi, 2006; Khovanskaya et al., 2013; Lupton, 2013; Sanches, Kosmack Vaara, Sjölinder, Weymann, & Höök, 2010; Thomaz, 2013). One of the consequences is that people's contact with lived bodies is constantly mediated via digital tools and sensors, and thus individuals can lose the capability to understand and trust the direct sensual information from their bodies. Inevitably, lived bodies and body awareness are disappearing behind numerical data of devices. Scholars (e.g., Khovanskaya et al., 2013) have concerns about whether these interfaces of personal health informatics enable long-term behavior change or simply narrow the definition of healthiness to easily quantifiable metrics. One relevant question to consider is how easily biomonitoring develops compulsive behavior in users who may have tendency to develop, for instance, *orthorexia nervosa*, a fixation on righteous eating.

Interestingly, fitness trackers are a highly intimate, personal technology, yet, in a way, they distance people from their lived bodies to collect and store personal data about their physical bodies. And as this analysis has suggested, perhaps various tools, based on big data outputs, can be developed for new control systems for behavior in the future. When the user's intentionality is focused on monitoring the fitness tracker, this activity simultaneously assists in alternative ways to process big data. Following the notion of HDI, embodied interaction design should not be exclusively fixed on studying user–device relations or toward any specific contextual circumstances of use. Instead, the primary starting point should be set to the streams and traces of big data and their connections to the affective microchoreographies of users. From this stance, devices are not accounted for in terms of how they influence immediate embodied activities but in what kind of invisible loop users are immersed at the institutional level.

When direct interaction with the environment and other people decreases and becomes more mediated via digital devices, this might move individuals towards more abstract, information-based, and cognitive-driven activities. In this context, actions are often seen as a means to input information to a device so that it could output or perform something for people. When people increasingly value exact information on their physicality—at the expense of their lived bodies and affective connections with other people—they are also in danger of ultimately weakening the very abilities to appreciate their own intuition and judgment.

IMPLICATIONS FOR THE THEORY OF INTERACTION DESIGN

The implications for theory of interaction design created by this article concern a new choreography-based analysis method that can capture movement as a reciprocal and dynamic matrix between humans and technology. In bringing together phenomenological methodology and Latour's actor–network theory, choreography is seen to arise from the relations of actants and becomes perceptible through movements, motion, patterns, and rhythms. Discussions of the choreographic matrix between the intimate act of biomonitoring and the generation of big data can concretize how human interaction with objects reaches beyond immanent embodied experiences. However, in this assemblage, embodied connections with digital technologies modify physical and lived bodies, forming new kinds of embodied practices and policies. This choreography-based approach can capture feedback systems—not just in how biomonitoring generates big data, but also in how the streams of big data turn back towards consumers and citizens. This approach can make more visible why personal data is not solely a personal issue and how big data is involved in embodiment and agency.

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YAMOVE! A MOVEMENT SYNCHRONY GAME THAT CHOREOGRAPHS SOCIAL INTERACTION

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Abstract: *This paper presents a design case study of Yamove!, a well-received dance battle game. The primary aim for the project was to design a mobile-based play experience that enhanced in-person social interaction and connection. The game emphasized the pleasures of mutual, improvised amateur movement choreography at the center of the experience, achieved through a core mechanic of synchronized movement. The project team engaged techniques from the independent ("indie") game development community that proved valuable in tempering the constraints to which technologically driven design can sometimes fall prey. Contributions of this work include (a) presentation and discussion of a polished digital game that embodies design knowledge about engaging players in mutual physical improvisation that is socially supported by technology, and (b) a case study of a design process influenced by indie game development that may help others interested in creating technologies that choreograph pleasurable intentional human movement in social contexts.*

Keywords: *technology-supported social play, meaningful and natural movement-based interaction, suppleness, sociospatial context, sociotechnical design, indie game development.*

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INTRODUCTION

Our research team is interested in expanding the social and emotional palette of everyday experience with technology—rethinking and redesigning the ways in which technology augments what people do together in more supple and graceful ways that better support physical and social engagement. We have found games and play to be a fruitful area in which to operate. The design of games and the development of gaming technologies privileges in-the-moment experience and allows for the deep relevance of positive emotional and social experience in evaluating success (Isbister, 2010; Isbister & Schaffer, 2008). Games are meant to be fun, thus good games have structural characteristics that promote the experience of fun, as has been noted by well-regarded sociologists and psychologists (e.g., Csikszentmihalyi, 1990; Goffman, 1959).

This paper presents a case study of the design of a particular game: Yamove! The project began in collaboration with Yahoo Research scientist Elizabeth Churchill, who was interested in exploring novel ways to use mobile technology and services to enhance in-person social interaction and connection. Our group had already been investigating the potential of physical play to encourage in-person social connection (Isbister, Rao, Schwekendiek, Hayward, & Lidasan, 2011). We therefore submitted a proposal to Yahoo Research to create a game prototype exploring the experiential potential of copresent movement-based social gaming. The target use scenario was casual play that would be accessible to a wide range of participants. Our goal was to create an experience that could support in-person social engagement between friends and families, as well as facilitate social connection among people who were less familiar with one another in contexts such as conferences or game exhibitions. Ideally, the game would be playable by a wide range of people of varying ages and movement capabilities.

The Yamove! project was originally meant to span half a year, culminating with in situ testing of the game in social settings such as academic conferences and company team retreats. What actually transpired was an 18-month process that deeply engaged independent ("indie") game development and playtesting strategies, leading to a final play experience that surpassed initial ambitions. Yamove! was featured at NYU Game Center's No Quarter exhibition. It was also an IndieCade finalist (the premier peer-reviewed venue for independent games in the United States of America). The game was also written up by game cultural critics (e.g., Narcisse, 2012).

What follows in this article is a description of the design process that led to this positive public reception. The case study draws attention to issues that arise when designing complex interplays of humans and technology in movement-based sociotechnical systems and highlights helpful work practices to address these challenges. Thus this case study can have value for researchers and practitioners interested in choreographing human–technology interaction both within and outside game contexts.

BACKGROUND

There is extensive research and design literature to draw upon concerning the shaping of rich physical and social experiences in collocated games (e.g., Bianchi-Berthouze, 2013; Hummels, Overbeeke, & Klooster, 2007; Isbister, Karlesky, & Frye, 2012; Isbister, 2011; Isbister et al., 2011; Johansson et al., 2011; Lindley, Le Couteur, & Berthouze, 2008; Mueller et al., 2011; Mueller, Gibbs, & Vetere, 2010; Mueller & Isbister, 2014 Simon, 2009; Tholander & Johansson, 2010). New technologies introduced within the last 10 years, such as movement sensors, have facilitated social and physical play, opening new markets and inspiring much research (Márquez Segura & Isbister, 2015). Yet, the dramatic initial public enthusiasm for commercial motion games seems to have dissipated over time (Moscaritolo, 2014; Tanenbaum & Tanenbaum, 2015).

Some researchers attribute this loss of enthusiasm to the constraints inherent in the technologies that were released, which narrowed the space of possibilities for movements and social dynamics (Benford et al., 2005; Loke, Larssen, Robertson, & Edwards, 2007; Márquez Segura, Waern, Moen, & Johansson, 2013) or "instrumentalized" the body too much (Höök et al., 2015). Other researchers point out that the typical technology-oriented approach to this design space omits important interactional issues (O'Hara, Harper, Mentis, Sellen, & Taylor, 2013; Tanenbaum & Tanenbaum, 2015). Trying to solve the representational problem of movements by focusing solely on being able to sense and model movements as accurately as possible (O'Hara et al., 2013) may not result in a better overall experience. Also, letting technology constraints overly determine the design process can lead to considering bodily aspects too late in the design process to make substantial changes (Tanenbaum & Tanenbaum, 2015). Limitations of a technology-oriented design approach are likely to be at least partially responsible for the dearth of examples of successful commercial movement-based social games that work well in a collocated social space.

Another facet of designing systems to support physical and social play is the social context where play takes place. Researchers have worked to understand how social context influences play and the play experience. Drawing from social psychology, research has shown how the sociospatial context influences the engagement of players, their excitement, and their perception of fun (Mandryk, Inkpen, & Calvert, 2006; Ravaja et al., 2006). It also impacts players emotionally (Jakobs, Manstead, & Fischer, 1996; Manstead, 2005). Finally, it shapes their perception of themselves, positively and negatively (De Kort & Ijsselsteijn, 2008), which, in turn, relates to players' performance (De Kort & Ijsselsteijn, 2008; Jakobs et al., 1996).

This stream of research has improved understanding of the social affordances of situated interactive play (De Kort & Ijsselsteijn, 2008; Jakobs et al., 1996; Magerkurth, Engelke, & Memisoglu, 2004). Yet there is still very little work that uses this knowledge as a generative tool for design (Márquez Segura et al., 2013). Yamove! is an example of a game that directly builds upon this body of literature.

METHOD

The work presented in this article lies at the intersection of design-oriented approach and research-oriented design (Fällman, 2003). The ultimate goal of the project reported here was to create a collocated social game that worked well for players; hence, the research conducted mainly targeted the refinement of the game application (research-oriented design). However, the iterative design process also yielded interesting insights that are applicable not only to the game design at hand but also to others in a similar design domain, which is characteristic of design-oriented research (Fällman, 2003). These insights are grounded in the empirical material, as well as in underlying theories, and are presented in this article in the form of design values and takeaways.

The design-oriented research process followed in this project resembled the classic iterative design process (e.g., double diamond design process model, n.d.). This process is characterized by alternating design loops, each involving a phase of divergence and one of convergence. In the former, several design aspects are considered, some of which are later implemented and tested in the convergent phase. Ensuing design loops further refine and polish the design.

The design process in Yamove! was characterized by rapid design-iteration loops, which meant frequent playtesting sessions. During the course of the project, nine playtests involving people outside the research team were conducted, as well as many regular internal playtests. It is not possible in the scope of a journal article to present the participants and procedures for each of these playtests in detail. Instead, an overview of methods used is presented here. Playtests generally took the form of informal evaluation sessions in which participants (internal to the group, or external) played the game and provided feedback. Playtests can be grouped into the following categories:

- Purely internal testing. Our project team playtested the design periodically throughout the process and intensively (i.e., every week) for several consecutive months.
- Lab-based testing. We staged events and conducted invited play sessions with external playtesters from the lab.
- Semipublic venue testing. We brought the game to design-testing environments where designers bring games in development for evaluation.
- Public exhibition. We brought the game to events where the public was encouraged to experience works in progress.

Data collection at each playtest included questionnaires distributed to the players, as well as informal interviews. (The latter were also conducted during demonstrations of the final design.) Both survey methods involved a mix of targeted questions (many in the form of Likert scale items on, e.g., the level of enjoyment or fun) and open-ended questions (e.g., eliciting strengths and weaknesses of the game, suggestions to improve the game). In addition, the playtest sessions were video-recorded for later analysis.

The video analysis performed was influenced by ethnomethodological approaches in sociology, such as conversation analysis (Atkinson & Heritage, 1984; Liddicoat, 2007) and interaction analysis (Jordan & Henderson, 1995). Thus, we focused on analyzing the sequences of actions and on details of the face-to-face social interaction in a fine-grained manner, such as the mechanisms that players used to accomplish joint action. For this, basic proxemics measures were noted (e.g., bodily orientation, distance between players and between players and screen, players' gaze; Marquardt & Greenberg, 2015). Finally, the video analysis used Laban Movement Analysis (LMA) to note basic information about the types of movements performed and their qualities (Guest, 2005; Newlove & Dalby, 2003).[1]

Two primary guiding design values framed the Yamove! design process from the beginning: suppleness and natural movement-based interaction. These were taken from our prior experience researching and creating games and other technology-mediated experiences to support social interaction. We also drew from others' findings in the domain of movement-based interaction.

Suppleness

Isbister and Höök (2009) previously introduced suppleness as a use quality to help guide the design and evaluation of interactive technologically mediated experiences. Suppleness is characterized by

- Subtle social signals. A supple interface is one that enables and possibly enhances subtle social signals that users engage in. A supple system could be viewed as a social/emotional ‘‘dance’’ with the end user.
- Emergent dynamics. A supple system fits smoothly and gracefully into a person’s social and situational context as he/she acts and interacts with the system. The system is able to adapt to and enable human improvisation.
- Moment-to-moment experiences. Supple systems privilege the quality of moment-to-moment experience in terms of both the design and the user’s evaluation of design’s success (e.g., a focus on engagement, pleasure, rapport). This requires flexibility in establishing the exchange between user and system.

Meaningful and Natural Movement-Based Interaction

Because we wanted to encourage and enable successful amateur movement choreography (i.e., improvised brief moves performed easily and successfully together), our work on Yamove! was also shaped by the guiding value of enabling meaningful and natural movement-based interaction. In our research, *natural* does not refer specifically to movements typically found in everyday life. Rather, it refers to movements that are easy to learn and execute and do not feel so awkward or arbitrary that they detract from the experience. Many scholars discuss the concept of natural interaction (Buxton, 1988; Isbister & Mueller, 2015; Norman, 2010; O’Hara et al., 2013; Saffer, 2009; Wigdor & Wixon, 2011). Although there is no commonly accepted definition of what *natural* means (O’Hara et al., 2013), the guidelines in Wigdor and Wixon (2011) were found helpful in shaping the movements parameters for Yamove! Some key guidelines are to

- create an experience that feels just as natural to a novice as it does to an expert user,
- create an experience that is authentic to the medium, rather than purely mimicking real world motions and interactions,
- build a user interface that considers context, including the right metaphors, visual indications, feedback, and input/output methods for the context,
- avoid simply copying existing user interface paradigms,
- leverage the user’s innate talents and previously learned skills,
- consider the context of use carefully (including spatial and sociocultural factors), and
- be mindful in social contexts of the need to support multiple people working closely and collaboratively together toward a common goal.

RESULTS AND DISCUSSION

Because of the iterative nature of the Yamove! design process, our results and discussion are presented together in one section. Appendix 1 provides a table with a complete timeline of all playtests, together with brief details of each venue, version of the game, players, and method, as well as a summary of the main observations and points for action. The table highlights the experiential qualities and observations related not only to the design of the application, but also to the particularities of the settings where Yamove! was playtested.

What follows here are highlights that illustrate the evolution of the design process and thinking on the project, providing the most relevant information for others in the research and design community. We will gladly provide more information to interested readers about any of the playtests that were conducted. Results are presented in two design phases. These phases were not planned ahead of time but rather reflect two distinct mindsets regarding the design process. The second phase was marked by the inclusion of a new team member and accompanying new ways of working (described in greater detail below).

Phase One: Playtest, Iterate, Exhibit

The first version of Yamove! was a cooperative, two-player game app for iOS devices such as the iPhone and iPod.[2] Players launched the app and then were instructed through on-screen text on their mobiles to quickly choreograph and perform a move together—a set of motions tracked by the mobile devices' accelerometers. They were prompted by a suggestion, such as "Make it Rain," and then had to perform this move simultaneously and as similarly as possible during a short, timed round; they could communicate verbally and nonverbally to achieve this. Players were scored on how well they synchronized their moves, with some upward adjustment of their score based on keeping up movement intensity. Figures 1 and 2 show a screen-by-screen overview to give the reader a detailed understanding of interaction flow for Yamove! 1.0.

The initial research plan was to playtest this prototype and make refinements to the game, with the goal of conducting a public exhibition a few months later. The first public playtest was held at Eyebeam, an art and technology gallery in New York City. Thirteen people agreed to try the game[3](see Figure 3). We made video recordings of these play sessions and players completed a brief Web-based survey about the game afterward. In addition to general questions about the gaming experience, this survey included questions aimed particularly at providing social support

Figure 1. Screenshots of the steps taken to initiate play in Yamove! 1.0. Players first launch the app, then pair their devices. Next they select a movement prompt (Make it Rain or Disco Inferno—see first screenshot). Then they see more details about that movement prompt (second screenshot). If they have decided this is the movement prompt they want to use for improvisation, they click "We are ready." At the next step, players click "Start countdown" to begin their movement session. The last screenshot shows the time clock running down while the players are moving together during the play round.

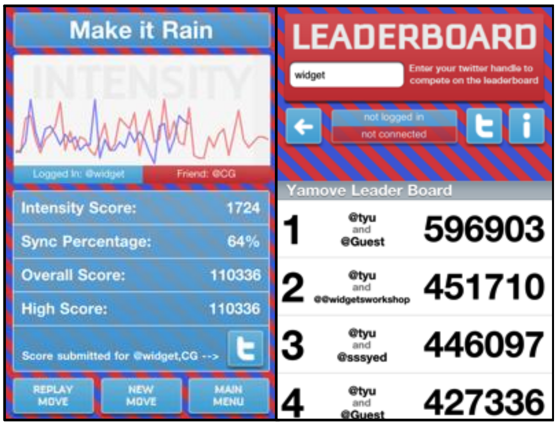

Figure 2. Further screenshots of the Yamove! 1.0 interface. When the round is over, players see the game results screen on the left, which includes their intensity score, sync percentage, overall score (i.e., the intensity score multiplied by the sync score), and a detailed graphic showing the intensity data for both players in different colors. The right image presents a leaderboard, reachable from the Main Menu, which gives a list of the top 10 all-time scores from any pair of players who has ever interacted with the game.

Figure 3. First playtest of Yamove! 1.0 at Eyebeam. Though players reported enjoying engaging in the joint performance, once they began and were able to synchronize improvised movements (see left image), the moves appeared somewhat socially awkward (see, for example, right image).

for gameplay. In their responses, players noted some usability issues with the game's interface and some issues with the deployment of the game, especially in terms of setting up game sessions and in understanding scores. Overall, they reacted positively to the central activity—choreographing movements together. Video data provided evidence of laughter and engagement; survey responses included comments such as, "*We had fun moving together and sharing enthusiasm for the game*." There were many suggestions for providing better social support within the game. For example, players suggested adding a location-based system that could alert a player when another potential player was nearby. They also suggested providing social rewards, such as a buddy pyramid system displaying the evolution of social connection with dancing partners. They also recommended adding public scoreboards that could be shared on platforms like Twitter and Facebook.

Considering the project team's guiding design values of suppleness and naturalness, we found a mix of positive and negative takeaways from this playtest. Players were readily able to improvise together and visibly enjoyed it; thus the central activity of making up moves was working well. There were user-requested changes aimed at improving the flow of the application itself. Upon reflection, the core game experience appeared somehow socially awkward.

Onlookers were not entirely sure of what was going on, and each player pair needed to be coached on what to do, at least to start. The game did not seem to encourage ready participation through observation. As a result, the research team thought that adding social support features within the app could help to address this.

The next iteration of the game integrated a Twitter-based leaderboard that could be accessed via the Web, to encourage extended social interaction around the game. Further, the graphics and interaction processes were streamlined and modified to address some basic usability issues. The team worked toward a summer release of the game on the app store, along with some public displays and feedback. Someone connected with our lab noted an upcoming event at a local indie games collective, F*%k the Screen, which was focused on collocated social play experiences. As the name of the event suggests, the theme of the curated collection of games was play experiences aimed at avoiding the typical gaming situation in which people sat and stared at screens without interacting closely with one another. The event organizers offered to include Yamove! in the event.

The game was demoed there for several hours alongside other featured games. Attendees could move freely between all the games, playing whatever they liked for as long as they liked. In this environment, the problem of social awkwardness identified in the first public playtest was even more pronounced, despite the addition of the Twitter leaderboard. Playtesters had to actively recruit players and walk them through what they needed to do. In contrast, large enthusiastic crowds formed around other games at the exhibition.

From observing and analyzing the differences between Yamove! and other games available that night, the research team had two insights about what Yamove! seemed to be missing. First, Yamove! was not a legible spectacle in the sense that it was not addressing the broader set of people in the room—observers and potential future participants (Reeves, 2011; Reeves, Benford, O'Malley, & Fraser, 2005). New players of other games at the exhibition were readily able to sort out what to do by observing the players' actions, and the performance of the game was an engaging spectacle in and of itself. In Reeves et al.'s (2005) terminology, the other games included "expressive interfaces" in which actions and effects were clear to the audience. Playing in a public setting is always also a performance (Dalsgaard & Hansen, 2008; Reeves, Sherwood, & Brown, 2010), and the other games at the event included design elements that presented play as performance and spectacle for the audience better than Yamove! did.

The second insight was that, even though the exhibition was organized as a rebellion against overreliance on screens, all of the games except Yamove! made use of a large shared screen as one component of the player feedback system. The exclusively small-screen interface for Yamove! meant that players spent significant time looking not at their coplayer but rather at their individual devices to take actions and figure out what was going on, which negatively impacted gameplay. Moreover, this made Yamove! less transparent to spectators and therefore less apt to generate and maintain collective attention. These two insights also led us to identify and incorporate a third design value moving forward: designing technology-supported play in a sociotechnical space of affordances.

New Guiding Design Value: Technology-supported Play in a Sociotechnical Space of Affordances

Márquez Segura and Isbister (Isbister, 2012; Márquez Segura & Isbister 2015; Márquez Segura et al., 2013; Mueller & Isbister 2014) and many others (see, e.g., De Kort & Ijsselstjein, 2008; Ducheneaut, Yee, Nickell, & Moore, 2006; Voida & Greenberg, 2009; Zangouie et al., 2010) have been researching and designing social play experiences that are augmented by technology. In the course of our research, however, an important design value emerged: technology use to support rather than entirely sustain social interaction and play (Isbister & Mueller, 2015; Márquez Segura, Turmo Vidal, Rostami, & Waern, 2016; Márquez Segura et al., 2013). This concept comes originally from Waern (2009). The intention is to use technology as one of many elements in the service of the overall target experience for players. Tholander and Johansson (2010) noted how a game experience sustained only by the technology can result in a very artifact-focused interaction, with everyone's shared attention fixated on the technology rather than one another. As the design of Yamove! moved forward, we wanted to make sure to support and sustain the players' mutual attention and their and the prospective players' (i.e., spectators) engagement.

As pointed out in Márquez Segura et al. (2013) and De Kort and Ijsselstjein (2008) regarding designing social games, it is important to include sociospatial elements as design material. Such elements involve, for instance, the spatial configuration of players, assigned roles for players and spectators in enacting the game, physical artifacts, and the play space itself. Hence, the technology is only one among many elements that are orchestrated in the final design of the play experience. But if the technology is just one designed element, what else could and should be designed?

De Kort and Ijsselsteijn's (2008) concept of sociospatial characteristics emerged as a useful frame for understanding the influence that contextual physical and social circumstances have on play and the play experience in Yamove! This concept relates to Dourish's notion of space, as presented in his book *Where the Action Is* (Dourish, 2001). Both of these texts point to how social and spatial features create a space for interaction with sociotechnical affordances that shape interaction. Elements such as the presence and position of others in relation to the user, everyone's bodily orientations, and the surfaces and digital and physical objects present in the activity shape the perceived affordances for action, and hence behavior. As Dourish put it,

> "Space" is largely concerned with physical properties (or metaphorical physical properties). It concerns how people and artifacts are configured in a setting, how far apart they are, how they interfere with lines of sights, how actions fall off at a distance, and so on. By configuring the space in different ways, different kinds of behaviors can be supported. (Dourish, 2001, p. 89)

But behavior is also influenced by the designed aspects of the game itself, such as the rules and goal of the game, the roles of the players, player interaction patterns supported in the game, and particularities of the game interface, such as input/output mechanisms and controllers. All this shapes the social affordances of the situation (De Kort & Ijsselsteijn, 2008), as they "allow for social interaction processes such as awareness, monitoring, mimicry, reinforcement, verbal communication and nonverbal immediacy behaviors (i.e., approach behaviors that reduce psychological distance (Mehrabian, 1981)" (De Kort & Ijsselsteijn, 2008, p. 5). Both the sociospatial context and social affordances form the "sociality characteristics" of a game, a term that De Kort and Ijsselsteijn (2008) borrowed from Jakobs et al. (1996), and which in turn impacts the play experience.

Phase Two: Re-envisioning and Iterating Using an Indie-Influenced Design Process

Working with our new guiding design value, we made the decision to focus further on the in-person social context for gameplay, rather than supplementing one-on-one interaction through social media interventions such as the Twitter scoreboard. We invited Syed Salahuddin, one of the founders of Babycastles,[4] the organization that had curated the F*%k the Screen event, to collaborate with us on reimagining the game in a way that better supported copresent social interaction and engagement.

In addition to design insights, Syed brought a work practice to the project derived from his experience in the indie game development community. As others have observed (Simon, 2009, van Best, 2011), indie game design follows a participatory-culture-like bricolage approach. Indies also make use of a bottom-up crafting approach to design and development, working from materials and skills that are ready-to-hand rather than beginning from user/player needs and use cases (Westecott, 2012). This shifted our subsequent design practice toward these ways of working, including

- a design and development process shaped and focused through frequent reference back to the target aesthetic experience for players;
- a more crafts-like view of technology as the means-to-the-end experience and with a willingness to revisit (and abandon, if necessary) technologies and designs that were not working well in serving the desired player experience;
- a design process that considers the social, spatial, and cultural context as design material;
- a multifaceted participatory culture approach to playtesting and iteration, with frequent internal testing, critical workshop sessions with peers, semipublic peer critique, and continued refinement through public exhibitions; and
- pushing design and development toward a high degree of polish through repeated exhibitions, culminating in peer-reviewed exposure of the work itself.

These process techniques proved to be very supportive in achieving the design values we had set for ourselves in moving forward on development.

In brainstorm sessions following the F*%k the Screen event, Syed suggested a better framing for the core synchronous movement mechanic by embedding it in a classic b-boy style dance battle.[5] Making the game into a dance battle had the potential to address two major problems that surfaced at the exhibition: It would make the gameplay more legible and comprehensible to spectators, and a face-off between two pairs of dancers would provide better direction for the collective attention of players and spectators. B-boying is highly improvisational in nature, so this frame was a good fit for the amateur choreography activity already in place. Syed also proposed the use of a large shared screen to post information about the players as they danced so that they and the spectators could get a sense for who was dancing better during the ongoing round and to increase excitement and suspense.

These ideas resulted in radical changes to the design and the technical infrastructure of the game. The final version of Yamove! is a four-person dance battle game, with two pairs of players alternating in performing improvised moves over three rounds[6] (Figure 4). Instead of reading a text description of moves to perform, players make up their own moves to music that is curated by a live MC (Master of Ceremonies, a term used in the dance battle culture).

Each player uses a dedicated mobile device, but we constructed a means for the device to be strapped onto the wrist to make free movement easier (Figures 4 and 5). The two pairs face off on a dance floor in front of a large screen that is designed as part of the game. This screen updates how the players are doing both within and after rounds (Figure 6). The mobile device interface was greatly simplified to minimize the amount of time that players would need to look at the small screen (see Figure 7). In practice, players are not expected to look at the in-game countdown nor at the large screen during play because they are receiving verbal feedback from the MC about how they are doing during and after rounds.

From a technology perspective, the game is no longer packaged as a pure mobile app. Instead the game is played using a combination of software. There is still a mobile app that each

Figure 4. The 2.0 version of Yamove!, shown during the World Science Festival public exhibition. The dance space was demarcated by colored areas on the floor, and dance pairs faced one another in front of a large shared screen. The MC worked at a table to the right, selecting music and calling out instructions to players. The left figure shows how the dedicated mobiles were worn on the players' wrists, while the right figure shows a full dance battle with the teams facing off.

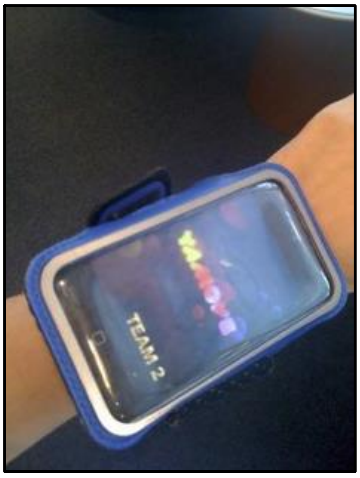

Figure 5. In the 2.0 version of the Yamove! game, the dedicated mobile device was worn on the wrist in a holster secured over a sweatband.

Figure 6. During Phase 2 in the development of Yamove!, a large shared screen was added to the gaming environment. The left screenshot shows feedback on the active team's progress during the round. When the round was complete, the right screenshot provided each team's dance outcome in regards to creativity (variation in moves), intensity (speed of moves), and synchrony of moves, all as calculated by the device.

Figure 7. Screenshots of the mobile interface for the 2.0 version of Yamove! that the active player pair would see during a round. Left, the mobile's screen indicates which team is currently active. The second left screenshot shows a quick countdown toward the beginning of the active team's dance round. The center screenshot indicates the countdown of the seconds left in the active team's round. The screenshot in the 2nd to right position provides a play-in-progress screen that bridges the end of the round and the display of the calculated score for the active team. The right screenshot displays a simplified final score screen. The 60 is a rating from 1 to 100, derived from a weighted combination of the three scoring factors (see Figure 6 for those factors).

player launches, but the dance rounds are controlled with a moderator app driven by an iPad interface. There is also a Web-server-based display app used to drive what is shown on the large shared screen. The moderator app was implemented on an iPad for easier managing by the MC or another operator.

The final version of Yamove! is an engaging experience for both players and spectators. The player's attention is focused on his/her partner during the dance round or on the competitor team, instead of on the small screen. The dance battle is a social frame that works for players and spectators, and well-curated music and artful emceeing creates a lively and festive atmosphere for play. Staging the game involves other atmospheric elements to heighten the sense of a dance battle, such as dance platforms and lights. The core coimprovisational amateur choreography activity that was fun and well-received in the first version of Yamove! remains, with additional social framing to make the performance comprehensible in a social sense and workable as an engaging spectacle. Feedback to players and spectators is optimized in managing attention so that the spotlight is on the players and their moves.

What follows next are some highlights from the iterative design process in the second phase of development that took Yamove! to completion. We have organized the results and discussion from the extensive series of playtests in Phase Two around three overarching design themes: optimizing feedback for social suppleness, from mobile to wearable, and shaping the social atmosphere.

Optimizing Feedback for Social Suppleness

The design team made many large and small changes to Yamove! to optimize in-play feedback for players, thus creating maximal suppleness in social interaction. For example, the metaphor of the b-boy dance battle led to the insight of adopting of a human MC to give players instructions and feedback. In the first implementation of the MC concept, an automated voice was used to vocalize tips for improving the scores presented on the shared screen (and tested in the Halloween lab and the playtests at Parsons; see Appendix). However, players had difficulty discerning this verbal feedback over the music. Then, during a weekly internal playtest at the lab, the design team experimented with calling out instructions over a microphone and discovered this improved players' understanding and ability to adjust to during rounds. The game was revised to include a live MC role.

During weekly internal playtests, we compared Yamove! with a commercial dance game, Just Dance, to see whether Yamove! produced observably more supple social interactions. Twenty students in a Human Computer Interaction class at our university[7] took part in an exercise in which each student tried out each game for one round. Conducted in our user research lab, the test allowed students to choose their partner for each round of Yamove! gameplay and when to step in for a battle. For the Just Dance play, songs were selected that allowed four players to dance at once, with each student taking part in dancing through one song. This test was videotaped, and we analyzed the interaction patterns that emerged.

Just Dance is a Kinect-based game in which dancers line up and try to mimic the dance moves modeled by an on-screen avatar (see Figure 8). Players must closely watch the avatars in order to make sure that they are keeping up with the moves. Each player has an individual score, so the reward mechanism is very different than the team-based score in Yamove!

The Yamove! version tested had a only single round, but we had already integrated the big screen feedback and the MC role. We expected that Yamove! would result in more player and spectator attention on the dancers rather than the screen, which is what we found. With Just Dance, the players and audience primarily stared at the screen throughout the round. However, Yamove! players usually were looking at the opposing team, one another, or sometimes at the spectators; the spectators mostly watched the dancers. Sometimes, when the pair was not actively dancing, they looked at the scoring on the screen or at the MC; other times they would rehearse and not pay attention to the active round.

In this particular test of Yamove!, in addition to the MC, we had a dance model performing moves that the players could imitate if they wanted. Our analysis showed that a slight majority of

Figure 8. Just Dance, a Kinect-based dance game, requires the player to imitate the moves of an on-screen avatar.

Yamove! players (6 out of 10 pairs) would take up the suggested move, but some would then give it a twist (4 out of 6 pairs). For example, the dance model might call out *Swim!* and show the players a breast stroke, but the pair would end up doing the crawl stroke together instead. As the round proceeded, half of the pairs danced moves not suggested by the dance model. At this point their attention was focused on one another. The data show that, typically, one person would initiate moves in leading the dance and the other would adapt to these moves. The leader then readapted moves based on what the two could pull off together. This process led to close mutual attention upon one another, one of the goals of our core game mechanic. Sometimes the leader looked out at the audience as she/he improvised, seeming to gauge the crowd reaction to a particular move. With one dancer, this came at the expense of turning his back toward his partner, but this was atypical. Overall, four pairs seemed to primarily mirror the dance model; four pairs seemed focused on one another, with one person as the clear leader; and two pairs were so in sync that it was difficult to tell who was leading. Interestingly, these same two pairs also did the most rehearsal before their rounds.

At the end of a Yamove! battle, most eyes would turn to the screen to see the final tally, but during the action, the focus was on the dancing itself. The Yamove! feedback system was working to keep spectator attention on the dancers and to keep dancers' attention on one another. Both actions demonstrated the increased overall suppleness and social engagement of the experience.

An unexpected result was that the quality of the movements was quite different between the two games. Yamove! movements were less jerky, more smooth, and more complete and graceful than moves performed with Just Dance. Therefore, the Yamove! dancers made for a more enjoyable spectacle and a greater appearance of mastery. Most Yamove! pairs (7 of 10) used primarily upper body movements, with less footwork. Their moves were large scale and determined looking and more fully and frequently synchronized, with only one pair performing vague and imprecise movements. Movement changes were caused both by the dance model giving a new cue (aimed at allowing pairs to improve their diversity score) and by one of the dancers spontaneously doing a new move. Yamove! players were able to improvise moves they could do well and could set the pace for their moves; adjusting as needed to one another's performance helped make each look good. Thus, Yamove!'s feedback systems had the added benefit of enabling more supple individual dance performance.

The Just Dance play was structured very differently. Although the game presented paired figures on-screen, suggesting teams, and the choreography often had moves designed to look good between a pair, the game scored each person individually and showed an individual winner of each round based on accumulated points. So the core game mechanic was really individual performance. Each group of four would choose a track to dance to, and each track had different choreography and imagery to suit the music. Silhouettes of dancers on screen were meant to map to the four players; the dancers needed to keep their attention on the screen in order to closely imitate what their own avatar was doing. Therefore, Just Dance player movements looked quite vague, indecisive, half-formed, and often a bit rushed, with an emphasis on the end pose or distinctive features of a movement rather than on the qualities and nuances of that movement. Most players were just going through the motions and trying to keep up, rather than putting a performative spin on their movements. Each round lasted for a 2- to 3-minute song and the choreography was repeated within the songs. Players seemed to perform moves with less intensity and enthusiasm as the choreographic moves came around again and again. Some of the moves were pretty easy for players to pick up—usually moves that were slow, had symmetry in the body, or used some anchoring reference in the song (e.g., drawing a star when a star was mentioned). Other moves seemed embarrassing to the dancers to perform (e.g., lying down and swinging one's legs). Players would simply skip these moves and wait for the next one. Sometimes this embarrassment seemed to be gender specific. For example, male players did not perform a sexy shoulder shake but the one female player did perform it.

Dance steps that required footwork or moving around on the floor were not fully executed. Players would shift their weight to mark these moves in some way but would not do the required detailed footwork. This could be due in part to the fact that the four dancers were crowded side by side to be within range of the Kinect. But, in general, complex moves were simplified as players focused on keeping up with the avatar on screen. Moreover, there was little in the way of mutual movement. Some of the on-screen choreography created pair focus, for example, with one avatar leaning in toward another, pretending to tell a secret. The dancers made half-hearted attempts at these maneuvers, but it was hard to execute them well.

Our conclusion from this comparative playtest was that we succeeded in engineering a better pair experience, as well as improving the social experience around the game. Yamove! pairs were more attuned to one another and produced more decisive and fully articulated movements together, which made for a more interesting group spectacle. The moderate use of the big screen did not seem to pull the attention away from the dancers, as what happened with the Just Dance players. Dancers were able to use the dance model as a starting point, but felt free to switch over to their own moves when it was comfortable, something impossible for players within the core design construct of Just Dance. In essence, Just Dance (and other games in this genre) forces players to adapt themselves to the on-screen avatar and prearranged choreography in order to succeed; players have no room or encouragement for individuation. And there is very little chance for any pair synchrony or bonding, given that everyone's attention has to be riveted to the screen at all times in order to keep up. No matter what was happening among the players, the onscreen avatars in Just Dance always overacted the moves they showed players with high enthusiasm. This could be off-putting to players if they were struggling just to master a move. In contrast, the human dance model for Yamove! could adjust suggestions for players, and the impromptu leader within the pair could further modulate these move choices to ensure the dance was achievable and enjoyable for both players. Although these adaptations might not have impacted the final score, which is based on intensity, diversity, and synchrony rather than complexity or precision, it improved the player and spectator experience. In essence, Yamove! had built-in flexibility to adapt to dancer ability and the general mood of the crowd.

The many changes we made during the course of the second phase of design dramatically increased the social suppleness of the game. The feedback systems, incorporating human feedback as well as machine feedback, and the judicious use of the large shared screen created a more engaged and connected experience for players.

From Mobile to Wearable

The final version of Yamove! positions a mobile device on the player's wrist in a holster that is worn over a sweatband. During the November and December playtests at Parsons, we noticed that players' movements seemed a bit awkward because they had to hold the dedicated mobiles. In the lab, a team member who used a mobile holster when jogging suggested trying out whether these could work for the game. Multiple trial and error play sessions led to the decision to put the holster on the wrist, with a sweatband beneath to hold it in place. In testing at public exhibitions, differently colored holsters were used to make it more clear which devices were paired for the dance battle. Strapping the holsters on was an exciting suiting-up ritual for game play and readily set players apart from spectators. Wearing the device in this manner also seemed to discourage players from engaging it as they would their own smartphone or iPod, making it less likely that they would poke at the small screen or fixate on the data and options available there. Instead, they limited their attention toward the mobile's screen to brief glances in between rounds to see their round score before it had made its way to the big shared screen. With the revised design, we essentially ignored most of the mobile's interaction capabilities, using it instead as a wearable sensor with a nice display screen. This was a radical departure from the Phase One design, and one that would have been very difficult to come to without using the indie strategy of bricolage and repurposing technologies and of freely adding unorthodox elements to get to the target aesthetic experience.

Shaping Social Atmosphere

Once we shifted to the dance battle frame for the gameplay, we began incorporating elements of a dance party into the design of the gameplay setup. For example, in the first playtest of the new concept, conducted at an open house party in the lab, we set up special lights, curated spooky dance music, and added a special Halloween splash screen for the app (see Figure 9). However, only a few people came to the party, and we ended up with stilted social interactions around the game—one or two people waiting for others to show up to play, lab visitors feeling awkward playing with one another, and pauses in the action as the equipment had to be restarted due to glitches. (In this playtest, we only had two devices that had to be reset between rounds, which took time and dampened enthusiasm.) This test demonstrated the need to carefully frame the experience for players, building excitement and enthusiasm through a well-paced experience. We also realized the game needed a critical mass of willing players in a social setting where they could feel comfortable dancing with one another.

Figure 9. The Halloween playtest had some, but not enough, of the social atmosphere elements for successful engagement by potential game players.

Our next two playtests were at Parsons/The New School. The first was for a Game Club night; the second was for an open playtest for designers in a graduate program. For these tests, we had four devices ready so the play was not delayed for resetting between pairs. We also introduced a list where people could sign up for a round with a friend, which also allowed them to prepare for participating. The outcome from both tests was encouraging: Players engaged the game with enthusiasm and, at times, it was difficult to get them to stop dancing at the end of a round. Several players reported feeling more energized and positive after playing. We attributed the smoothness in the flow of these playtests to the decision to explain the game in advance and to encourage participants to sign up for slots, which framed the experience for them ahead of time and created a steady flow of dance teams.

In early April, the team invited a group of b-boys and b-girls into the lab to try out the game (see Figure 10). They really pushed the capacity of the sensors with their extreme dance moves. Watching them play the game was exciting and dramatic. Because of their prowess, we invited them to demonstrate the game at a lab open house, helping other players see the possibilities in the game. We worked with them to commission an MC who could perform at two future upcoming public exhibitions, as well.

Figure 10. Two b-boys demonstrate synchronicity in Yamove! gameplay as part of a playtest by a group of b-boys and b-girls.

Later that month, we had the opportunity to bring the game to another Eyebeam playtest. We decided to attend even though all the party elements would not be in place for this test (e.g., lights, elaborate sound system). For the first time during a test of the game, a couple of teams started to do very vigorous calisthenic-style movements instead of dance moves. They exhausted themselves halfway through the rounds, resulting in a poor experience for the users. This outcome highlighted for us the importance of the social elements framing the best way to play the game.

The staging of the game at the final events (i.e., No Quarter, World Science Festival, and IndieCade) involved a live MC who was also mixing music, trained dancers who could help model moves, and excellent sound and lighting. The positive impressions that players of these final events had of the game benefitted from these carefully sculpted social atmosphere elements.

IMPLICATIONS FOR APPLICATION TO DESIGN

One key implication of this case study is the value of collaborating with individuals and communities of practice who bring complementary expertise to a complex design task. In our case, the task was choreographing human interaction in a sociotechnical space composed of digital, physical, and social artifacts and actors. This implication resonates with previous findings in design research (see Fällman's, 2003, characterization of design-oriented research as one that seeks to explore possibilities beyond current paradigms). For designers, this requires being open to adjusting stated design objectives as the project goes along and to supplementing familiar design methods with additional methods and strategies. As noted by Stolterman (2008), design complexity is of a special nature (compared to scientific complexity) because design problems are often underdefined, and because it is impossible to explore all possible options or achieve a unique optimal solution. This is known in design research as a messy or wicked problem (Buchanan, 1992; Rittel & Webber, 1973; Stolterman, 2008). A valid type of inquiry to address this type of complexity is to be open to adjusting the problem framing during the process, as possible design solutions are generated (Bardzell, Bardzell, & Koefoed Hansen, 2015; Fällman, 2003; Schön, 1984).

In the case of Yamove!, including Syed as a collaborator helped address the wicked problem of designing an engaging collocated social movement experience. Syed's indie way of working was a fresh influence on the project. He encouraged us to broaden the technological frame in service of the experience—weaving other devices into the project in addition to the mobiles and changing our way of working with them. We were encouraged to ruthlessly iterate the game and our vision as designers through extensive and robust playtesting and assessment, working toward a level of polish that enhances the experience. This polishing of the game experience requires attention to and enhancing not only the technology used but also the social atmosphere that surrounds the interactive game. This is an important design element that facilitates engagement of both players and spectators.

Another takeaway from this case study is the benefit of the design values outlined in this article: the guiding use quality of suppleness, the guiding value of enabling meaningful and natural movement-based interaction, and the guiding approach of using technology to support rather than entirely sustain social and physical interaction and play in a sociotechnical space of affordances. These can be of use in focusing the design of both game-based and nongame technological support of in-person social interaction. Of particular importance is highlighting the third value: technology-supported play in a sociotechnical space of affordances. Although adopted in the middle of the Yamove! design process, it served as both a generative and an evaluative tool for design, helping us to continually refocus on whether and how the technology supported the core experience and what other nontechnological design elements could be leveraged to reach our intended gaming experience.

CONCLUSION

We have presented a design and process case study of Yamove!, a technology-supported dance battle game. This paper clarified the evolution of our team's design values and methods as the process unfolded. Changes included adopting an additional guiding design value and engaging in a much more varied and frequent schedule of playtests, evaluations, and design changes in the second phase of the project. These shifts were heavily influenced by the addition of a new collaborator with a complementary design practice and community. Overall, the changes in approach helped us better achieve and refine the design challenge and guiding design values that were in place at the start of the project. The changes also led to a novel final design that differed dramatically from the original game, exceeding the design team's expectations in terms of player and critical reception.

Yamove! began as a mobile-only app to support in-person social play and evolved into a multiperson, multitechnology dance battle game that included a live MC as well as a carefully crafted social atmosphere. The final version of Yamove! works quite differently from commercial games such as Just Dance by embracing the three guiding design values for the project—suppleness, meaningful and natural interaction, and technology-supported play in a sociotechnical space of affordances. Yamove! frames the mutual choreography created by dance pairs to shape an engaging and enjoyable play experience and social spectacle.

The outcome of our team's game design process—from establishing and adapting, as needed, guiding design values to incorporating an open, collaborative, and iterative testing and redesigning process—offers key contributions for consideration in future game design research and practice.

ENDNOTES

1. To simplify the wording in this article, we have opted not to include specific terminology included in LMA.
2. This project was built upon an existing game prototype created by master's students at Carnegie Mellon University's Entertainment Technology Center (Miller, 2010; see also www.youtube.com/watch?v=Ald-24xdzvo&feature=player_embedded).
3. See www.youtube.com/watch?v=PZBPj3_ew60 for an edited sample of some of the playtest rounds.
4. Babycastles is an indie game developers collective based in New York that promotes a crafting culture in game design and that has a strong influence from the broader art community in New York. This collective advocates for the identification, support, and exposure of new game design voices around the world (See http://babycastles.com/about.html). Babycastles events are attended by arts and indie game experts and they typically include music, dimmed lights, and cheap beers.

5. B-boying is a dance form that evolved in the 1970s in New York City. It arose at the same time as scratching/mixing records and rapping, and the forms were initially intertwined, co-existing at parties of the era. B-boying emerged from showy dancing to the between-lyrics music on records that a dj would scratch and mix at a party (Gorney, 2009; Vibe, 1999). Most people associate the terms b-boying and b-girling with improvisational dancing down on the floor, including spinning on one's head. However, the classic forms of hip-hop dance that are a part of the overall genre—including styles such as up-rocking, popping, and locking—are performed upright.
6. See the final version of Yamove! at https://www.youtube.com/watch?v=cpZ28lr9BqI
7. NYU (New York University) Polytechnic School of Engineering in Brooklyn (http://engineering.nyu.edu/)

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Appendix

As a word of caution, although this table is ordered chronologically, design iterations did not always follow the stereotypical design-test-analysis-implement sequential order. Sometimes, quick system iterations took place before there was an opportunity to fully scrutinize material from the most recent playtest.

Name, Date, Test Type	Playtest Details	Findings → Insight
Move It! playtest February Semipublic test	Version: original app Venue: Eyebeam/COAP monthly playtest event Goal: uncover strengths and weaknesses of the app Players: Other game designers and the public; 13 participants Method: video recorded pair play, followed by a Web-administered survey that focused on general experience and details of the interface	+ Amateur movement choreography core mechanic pleasurable + Participants enjoyed making up moves. - Missing social context - Confusion about effects, in particular the scoring mechanism -Screen-focused interaction - Not enough flow to support the core mechanic (menus and setting hindered flow) → Design value: social frame
F*$% the Screen! event July Public exhibition	Version: Yamove! 1.0 with refined graphics and scoring. Social frame built using social media. Add-on layer to the game included a Twitter-like leaderboard and log-in feature for the players so that they could share the outcome of the game in their social media. Venue: Babycastles[4] public exhibition playtest (see Phase One for description). Goal: evaluate social frame Players: 10 Indie designers and aficionados Method: Video recorded play sessions as they occurred.	+ Fun for those playing + Core mechanic + Sought bodily orientation (i.e., towards one another) instead of towards a big screen, like other games in this event. - Not as compelling as other games at exhibition - Challenge in recruiting participants - Failed to provide a legible (understandable) spectacle for audience - Failed to manage collective attention well - Compared to the other games at the exhibition, game triggered less expectation, less curiosity, less engagement for players, and less rich physical and social experience. → Re-framing the experience as a dance battle → Inclusion of new team member from indie scene → Design value: technology-supported → Design goal: sociotechnical space
Halloween test October Semipublic test	Version: First tests of new dance battle theme and some elements (music, dance pairs, dance atmosphere). Activity socially-sustained in part by: (a) creativity score awarded by audience on white boards, (b) experimenter resetting and handling devices, and (c) players selecting music. Artifact-focused interaction addressed by giving tips for improving dance technique using an automated voice from the application. Venue: Halloween lab party test Goal: check the dance-battle theme. Test implementation of social context with a Halloween themed party atmosphere. Players: 9 Lab members and visitors/Parsons students	- Significant awkwardness in players joining the game - Particularities of the room (only one entrance) caused a bottleneck for attendees, which did not allow attendees to see the ongoing activity inside the room. Curious attendees who came in further would suddenly find themselves in the spotlight, without many options to be in background and still watch the game. - Weak spectator-to-participant transition; people hovered but hesitated to participate (and many did not participate) - Music selection process (i.e., participants choosing a music track) disrupted the game flow because participants hesitated much - The automated MC voice-over implemented in the game faded in with the music

	Method: video recordings, participant observation, informal interviews	Participants exhibited more enjoyment and less awkward movements when rehearsing as compared to performing. Thus, while rehearsing: + Player configuration changed to a close bodily formation (Marquardt & Greenberg, 2015) facing one another in mutual orientation, which happened before and after the game. This formation allows the participants to act as if they were less in the “spotlight” because their actions are directed towards one another (and mostly visible by them), instead of and not towards the audience. This resulted in the participants looking more at ease with their performance. + Movements just “marked” and agreed-upon, not fully performed + The activity of coming up with movements was interesting for our team because of the type of interaction, communication, and closeness observed between players. → Contextual elements working well → Need to fine-tune the social support → Arrange space to avoid congestion → Create a more casual stage → Technologically, devices required less preparation from the team, which improved the flow of the game. Extra devices needed to smooth transitions even more.
Parsons test 1 November Semipublic test	Version: Same version as in Halloween test but with big screen for scores to invite participation and competition. No theme added. Venue: Parsons/The New School game club night, for designers to test games with club members, peers, and students. Games were playtested in rooms adjacent to the main open space where students are typically working. Rooms had see-through walls. Goal: Evaluate dance-battle theme Players: 12 designers, students, and members of the club Method: Participant observation, with recordings	+ Players enjoyed moving together + Use of displays for awareness (leaderboard) improved awareness and sparked competition - Participants shy and hesitant in general, but primarily at the beginning of the game - Players slow in formulating moves during competition - Slow management of turn-taking → Need to address the hesitation of players and the general feeling of awkwardness, which we associated with a disruption of the flow of interaction due to slow turn-taking.
Parsons test 2 December Semipublic test	Version: Same version as Parsons test but used 4 devices to smooth transition. Scores were normalized within a range from 1 to 100. Whiteboard provided for signups of pairs or individuals, with slots for competition times Social support: (a) experimenter with iPad to control the rounds among the devices (i.e., which devices were paired together and on for each round); (b) active recruiting through explaining game’s goal and the possibility to sign up, and (c) experimenter as a dance partner when needed for solo participants interested in a battle. Venue: The same as in Parsons test 1, but students were having final exams, which made a more challenging playtest environment (and the reason why the whiteboard sign up option was included). Players: 12 design students and friends	+ Smoother flow of rounds between teams + Stronger responses to scores + Coordination cues happening well + Players so engaged that they didn’t realize when it was time to stop round - Automated MC voice-over still faded with the music + Requests for more rounds within party-like atmosphere (dj, drinks, etc.) + Impromptu participation of those observing through the see-through walls + Participants reported enjoying the game, dancing with one another + Participants reported postcompetition positive feelings, e.g., energized + Some participants rehearsed before and after rounds + Participants’ theatrical engagement (victory signs, teasing the other team) + Fun, laughter, celebrated victories

	Goal: Check smooth transition between rounds and games Method: Participant observation; no video. Brief paper survey about general aspects of the experience, the app, and the game as a whole.	+ Four-player spatial pattern enhanced competition and improved flow → Framing experience beforehand was valuable (signup slots, active recruiting and explanation) → On the right track towards a dance battle game → Need for further refinement of party atmosphere (e.g., lights, beverages) → Design cues to clue round ending → Consider other human facilitators (e.g., dj) → Consider other methods to reduce barrier to stepping in, other than sign-up method, to support spontaneous participation → Consider spaces more open and visible to passers-by
Weekly internal lab tests to prepare for No Quarter exhibition January- May Purely internal tests	Version: Start with same version as Parsons test 2; small changes introduced following every playtest Venue: Weekly internal playtests (held during lab group meetings) Goal: Fix miscellaneous deficiencies, mostly in terms of technology Players: Lab group members (designers, researchers) Method: testing and informal discussion afterward	(Issue addressed → Strategy) - Awkward movements from holding device →Moved iPods to wrists - Social and physical awkwardness → Designed clearer structure to guide play - Improved game strategy → Design of multiple rounds for the dance battle - Simplified scoring → Focus on meaningful features: synchrony, intensity, and the diversity or range of different movements - Lacking player feedback system (e.g., voice-over tips lost or demanding too much attention → Improve social support through human facilitator for simple feedback at specific moments
Comparison with Just Dance March Lab-based test	Version: Game version similar to Parsons test 2; A single round of dancing; operator-controlled round, timed with an iPad, with additional social support from a person calling movements (instead of automated voice-over), the intensity/synchrony/creativity scoring system, in-the-moment feedback on the screen, and wrists holders for the iPod app devices. Venue: At the lab Goal: Comparison between in-progress Yamove! prototype and commercial dance game Just Dance Players: 20 students from an HCI class Method: Video-recordings of the activity. Video analysis based in interaction analysis: coded player bodily interaction patterns, bodily orientation, coarse body movements (i.e., body part moved), expressivity, and movement quality. Coded also general attention of the audience.	+ Attention of players and audience more on players with Yamove! versus on screen with Just Dance + Better articulated moves in Yamove! players + Improvisation in Yamove! players vs. mimicry in Just Dance players → Confirmed the design was working well through this internal playtest in preparation for No Quarter Exhibition
B-boy/B-girl lab test Early April Lab-based test	Version: same as in the Just Dance comparative test but improved use of shared screen (e.g., implemented countdown to start rounds and feedback between rounds) Venue: The lab's "living room" (i.e., a more casual and playful open space) Goal: Revisiting the theme of framing the experience with dance experts (b-boys and b-girls) Players: 6 B-boys or b-girls (i.e., people familiar	+ Players very comfortable with the dance experience, their bodies, the space (except non-b-girl, who was more shy) + Impromptu performances before, during, and after the game + More frequent footwork and floor work, i.e., dancing at various height levels + Vigorous movements, to the point of saturating sensor readings + Shifting roles of leadership (i.e., different than previous tests, where one person usually took

	with the dance battle form of Yamove!) and one non-b-girl friend of the participants Method: Video recording of playtest and informal interviews afterward; video analysis similar to the comparison study	leading role) + Players invested in scoring: commenting on scores, celebrated victories. + Liked room for creativity with the moves. + Good feedback about the game structure (rounds, sense of competition, scores) + Reported the game captured well the canonical b-battle style: spatial orientation and scripted turns - Players had difficulty synching movements during play because this is not common to their dance practices - Movements easier at the beginning, more complex as game unfolded - Bodily orientation toward the spectators, less attentive to their partners - Tendency toward "solo" types of movement not meant to be followed by the partner An exception to the later negative points happened in a case when one b-boy partnered with a novice. + Our team found the expert dancer role inspiring and useful as guide for the novice dancers + Different bodily orientation: towards one another, which we associated with an easier synching of movements + The expert dancer was observed to gauge the novice dancer abilities to follow; he progressively increased the difficulty of the dance, building from simple steps to more complicated movements. He used several strategies to scaffold difficulty, like using symmetric movements + Lots of laughter, smiles, teasing → Research team influenced by the observed role of coach to considered incorporating social mediator (i.e., choreographer to propose movements if active players become "stuck"). → Researchers asked b-boy/girl crew to participate in an open house and No Quarter playtests to encourage people to dance.
Eyebeam revisited April Semipublic test	Version: Resulting version from internal lab test, including improvements regarding holding of the iPods, rounds, scoring, and feedback system. Venue: Eyebeam/COAP revisited (same event as in the Move It! playtest): Open space in brightly lit warehouse Goal: Focus on testing the technological, design variations from internal lab tests Players: 15 expert users/designers Method: Video analysis similar to the comparison study: coded player bodily interaction patterns, bodily orientation, coarse body movements (i.e., body part moved), expressivity, and movement quality	+ Participants eager to play the game (e.g., difficulties with getting the music system working at the beginning of the playtest, yet players started to play the game anyways) Outcomes similar with and without music: - Calisthenic behavior instead of dancing - Music neglected, as players moved not in synch with the music's beat - Movements repeated - Focus on "scoring" through vigorous but simple movements - Less fun - Movements less likely to be in sync - Rehearsed and performed movements very similar (as compared to other playtests where performing brought in more expression and passion) - No dancing/party atmosphere - Reported enjoying moving together, but not really motivated to dance - Reported need of more game structure, more guidance → Reinforced importance of setting an atmosphere:

		establishing "the magic circle" (i.e., the dance floor) as something distinctive and separated from normal activity outside → Structured action both with technology design and social support
Lab open house Early May Public exhibition	Version: Inclusion of a human dance model. This role involved calling moves (like the MC) but also performing them so to inspire the participants (positioned next to the big screen). Several dancers, positioned next to the players, would copy the dance model's move to inspire the players Scripted "funny" moves, some of them complex involving several steps, e.g., fishing: gesture representing preparing to throw fishing line, throwing line, and reeling in Venue: Lab "living room" Goal: Testing the idea of using dancers as models to make improvising moves easier and more fun; fine-tuning game for upcoming exhibition Players: Members of university community and the public invited to try out different demos from people in our lab Method: Participant observation	+ Festive environment. + Reframed activity looked like a dance class + Interesting and fun dynamics when dance partners were experts - Complex moves suggested - Players focused more on following the model and less on coordinating with dance partner → Fine-tune role of the human dance model to offer inspiration instead of specific moves to follow → Use dance experts as dance partners?

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