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Poutanen, Olli; Ylirisku, Salu; Hoppu, Petri

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## TECHNOLOGY CHOREOGRAPHY: STUDYING INTERACTIONS IN MICROSOFT'S FUTURE VISIONS THROUGH DANCE

Olli Poutanen  
*Department of Design  
Aalto University  
Helsinki, Finland*

Salu Ylirisku  
*SDU Design  
University of Southern Denmark  
Kolding, Denmark*

Petri Hoppu  
*Media and Performing Arts  
Oulu University of Applied Sciences  
Finland*

**Abstract:** *In the future, an increasing number of devices will be utilized in concert to support human activities, but little is known about how these interacting multidevice settings should be designed optimally in a human-centered manner. We report on a study in which we took two visions created by the Microsoft Corporation as a starting point. The aim of the paper is to describe a method for user-centered design that extends the ideas of a choreographic approach to interaction design and to demonstrate how micromovement analysis can be conducted in practice. We utilized a structural reorganization of movement continua originally presented in the videos for a first-person enactment of that choreography as a means to understand the kinesthetic quality and the potential of the implied choreographies. The approach underscores the influence of interaction designs on the moving and experiencing body, as well as the potential that the moving and experiencing body has for interaction design.*

**Keywords:** *interaction design, intelligent environment, choreographic analysis, hermeneutics of the body, embodied mind, dance.*

## INTRODUCTION

Interaction design is moving from a single-device focus towards interconnected objects in intelligent environments (Gubbi, Buyya, Marusic, & Palaniswami, 2013). This study focuses on human–computer systems in which interplay occurs between the user and a combination of various form factors—for example, smartphones, tablets, screens, and smart objects, such as office accessories with inbuilt intelligence—that collectively constitute a communicating–actuating network. The enablers of the described interactions are embedded in the systems that are built upon logic that exceeds that of any individual device. The ever-increasing number of sensors, processing power, and communication capabilities of objects enhance everyday objects’ capability of producing a “deeper understanding of the internal and external worlds encountered by humans” (Swan, 2012, p. 217). The main challenge of designing environments that are capable of responding sensibly to the user’s actions is, as Rogers puts it, to make the numbers “intelligible, usable and useful” (Rogers, 2006, p. 412).

In this study, we focus on intelligent environments in which the user is given the role of an active agent who orchestrates the network of smart, interconnected devices to serve his/her needs. We argue that, when defining these systems from the perspective of user-centered interaction design, the moving, sensing, and meaning-making body of researchers and designers should be considered the core of the design research method. We describe an analysis method that quite literally puts the researchers and designers “into the shoes” of the user and increases their awareness on how physical setups of interconnected visual displays, moving application controls, and different haptic–tactile input and visual output mechanisms influence the user’s body during the interaction. Our focus is on the ways in which a designer or a researcher can explore and analyze the qualities of movement experienced by the user during interaction. We describe how we used the method to analyze a conceptual use context. The analysis data come from two Microsoft Corporation’s videos on intelligent environments, namely *Productivity Future Vision* (2009, 2011).

In this study, choreography is the central concept that serves both as a term of describing body movement in space and time, in which case it is useful in conducting practical movement analysis, and a concept that links our approach to mobile aspects of embodied methodology. Through choreography, movement can be analyzed both as an ephemeral action and a sustained, recurrent structure. The term *choreography* originates in the domain of dance. It refers primarily to the structuring of movement in space. However, it also implies a profound attentiveness to the body and its movements both on stage and in everyday life, where any movement or mobile action can be turned into choreography when performed by people trained in these activities, such as dance (Thomas, 2013, p. 3). Even within the field of dance, the concept of choreography does not merely refer to an external model or schema for structured actions, but the term has been expanded to encompass its frame and parameters, dancing bodies and their physicality, and processes of learning, as well as the ways in which the choreography is actualized and experienced (Foster, 2011, pp. 215–218). Furthermore, choreography is not limited to dance, but it is used to describe manifold embodied mobile processes, even the functioning of the brain. As J. L. Hanna (2015) suggested, the brain organizes sensory experiences, thoughts, and actions into meaningful entities, such as thinking, speaking, and dancing, which Hanna regarded as a complex choreographic process. Choreography may indeed point to the fact that the mode of cognitive organization is characterized by mobility

and, therefore, the concept of choreography can be seen as a valid tool for analyzing complex systems of human behavior (Mason, 2009, p. 32). Performed actions, as well as sequences of movement progression, can be encompassed within the term choreography.

The study of movement is not new to interaction design and research. Even as the focus in the field has shifted over decades from usability, user experience, and co-experience to embodied interaction (see Dourish, 2001), all these frameworks have considered the user's movement as part of the interaction. Understandably, the different frameworks' relationship to movement, as well as the scope and rigor of movement analysis, vary considerably among these traditions. In some approaches to interaction design, movement has been studied with special attention. This applies especially to movement-oriented interaction design (see Loke & Robertson, 2013). We acknowledge this background, yet we also claim that the role of the physical human body and the ways in which the acting body forms structures of movements in space, in interaction, and in environments with networked technologies has thus far attracted limited attention.

Not surprisingly, the scientific treatment of the human body in interaction design has its roots in the ontological, epistemological, and methodological structures of Western knowledge. Science has been regarded as belonging to the realm of cognition which, in turn, has been treated as nonembodied, that is, a matter of the mind. This, however, has been questioned by scholars from neurologists (e.g., Damasio, 1994) and linguists (e.g., Lakoff & Johnson, 1999) to dance researchers (e.g., Parviainen, 1998). Moreover, philosophers, such as Nietzsche ("there is more reason, sanity and intelligence in your body than in your best wisdom"; 1883/2010, p. 32), Heidegger (1975), and Merleau-Ponty (1945/1965), also aimed at challenging the dominance of logocentric knowledge in Western thinking. Interaction design that factors in the human body, its knowledge, and its versatile intentions in human-technology choreographies may positively contribute to the development of everyday environments.

It is challenging to define the interrelationship between bodies, movement, and objects in interactive environments. A possible starting point for understanding the nature of the interaction and for describing complicated embodied interrelationships is to count human beings as part of the "thing world." Thus, the body is characterized as the user of things that, in turn, can be considered augmentations of the biological body. The body and the things are thus characterized by constant coevolution in which the reach and the possibilities of the body are defined by the nature of the hybrids created (see Thrift, 2008, p. 10). Because the moving body and its intentional behavior are emphasized as constitutive elements of human-technology interaction in this study, the consequent definitions of interaction can be built upon theories in which the body, movement, and perception are seen as sources of knowledge.

The question of the embodied mind from the perspective of natural sciences has been studied by a number of scholars since the late 20th century. As a biologist, philosopher, and pioneer of the science of embodied cognition, Francisco Varela (1999) applied phenomenological analyses of time-consciousness to neuro-dynamic processes connected to the lived temporal experience of the embodied ego. Influenced by Varela and other scholars of the embodied mind, philosopher Evan Thompson (2007) stated that concepts, language, and thinking are based on embodied information: In other words, the lived body is the foundation of all knowing. Similarly, neurologist Antonio Damasio (1994, p. 118) concurred that the human body, not only the brain, is inextricably and comprehensively intertwined with the mind in the sense that the mind can be seen as embodied. Linguists, such as Lakoff and Johnson (1999), have developed similar themes

from the perspective of cognitive science, addressing how language and thinking have their deepest roots in embodied metaphors.

The embodied mind is tightly connected to embodied knowledge, a concept that emphasizes the body as the basis of knowledge. Michael Polanyi (1966) named the embodied dimension of knowing “tacit knowing,” which referred to the kind of knowing that cannot be completely articulated verbally, as it remains rooted in the human bodily abilities and expressions. Embodied knowledge belongs to the realm of nontraditional episteme, in which valid knowledge is not merely propositional. This was further demonstrated by Maxine Sheets-Johnstone (1999, pp. 490–491), who stated that thinking is essentially embodied in a way that is often a matter of movement, not of language, and, as a result, it is not restricted to mental capacities of the brain. Thinking in movement is not the work of a symbol-making body but an existentially resonant body that knows the world through its own kinesthetic qualia as well as the movement of the surrounding world (Sheets-Johnstone, 1999, pp. 516–517).

Embodied or tacit knowledge is often regarded as something that escapes verbal explication, which results in the phenomenon being difficult to recognize and analyze. This, however, is partly a delusion because language is not the only way to articulate interpretations of the reality. In this article, we argue that movement is an integral and natural part of human thinking and that it supports the organization of ideas in human–computer interaction. Movement serves as a means of documenting and reporting results that are easier to understand by looking at the enactment of the movement sequences. In this study, enacting micromovement continua formed an important step in getting access to the kinesthetic experience of human–technology interaction. Furthermore, performing movement sequences with awareness of specific technological contexts made it possible to concentrate on user-centered understanding of the mutual interplay between the user’s body and senses in interaction with technology. Microsoft’s videos *Productivity Future Vision* (2009, 2011) provided a visual reference for the technological settings. These videos provided comprehensive scenarios of how interactions between a user and a set of devices unfold in space and time. The videos are precise in representing movement continua, which makes them suitable for choreographic analysis. Because the researcher who danced the choreography (author Olli Poutanen) is very familiar with the Microsoft video material that presents the interactions in context, the enactment of choreography in this study also serves as a mediator between the felt essences of movement and the situated interactions.

The aim of the study is to extend the choreographic approach to interaction design introduced by Parviainen, Tuuri, and Pirhonen (2013) and to introduce a research procedure that supports conducting microlevel choreographic analysis in practice. The outcome of a choreographic approach enhances the design of human–technology interfaces that stimulate the imagination of the user with creative movement practices. Ideally, the choreographic approach facilitates the creation of such systems and configurations of networked products, services, and systems that enable users to become more expressive, effective, and productive. According to Parviainen et al. (2013), movement-based interfaces, actions, and the movements themselves may support the creation of sensitive or intelligent user-centered experiences. We find the ideas of choreographic approach very relevant, yet the descriptions provided in the literature do not provide a clear methodical framework for operationalizing the choreographic approach. We adopt the idea of micromovement continua by Parviainen et al. and extend it with another approach called hermeneutics of the body (Hoppu, 1999, 2005). Hermeneutics of the body enabled us to build a framework for conducting first-person enactment and for performing interaction choreography as

part of a micromovement analysis. An experiment of utilizing this approach is described and discussed below. The method development presented in this paper is based on a previous experiment (Poutanen, 2015); thus, the experiment is presented in a descriptive manner. The presented method contributes to the understanding of how the kinesthetic quality and potential of the implied interaction choreographies can be addressed through interaction design research.

## RELATED WORK

One of the pioneering documented works in the field of prototyping ubiquitous computing environments is reported by Johanson, Fox, and Winograd (2002). Their work outlined both design principles and aspects that need to be considered in evaluation. Their principles for the design of a ubiquitous computing room for teamwork included valuing the collocation of people and the materials they work with, the appraisal of the social conventions of the people, and the aspiration for simplicity. Using these principles, Johanson et al. created an interactive space with novel applications and computing devices that enabled them to study how people used these applications. They studied interaction with a special focus on three generic task scenarios: moving data, moving control, and dynamic application control. Johanson et al. concluded that one of the most critical aspects of the fluency of the space and interactivity is user learning. To facilitate success, users should not be forced to learn more than a minimal number of new controls and modes. We view this perspective as where both the embodied approach and the concept of choreography become very useful, in that designers can become aware of and build systematically on the existing repertoires of bodily conventions of users.

Iqbal, Sturm, Kulyk, Wang, and Terken (2005) studied how ubiquitous technologies could provide support for collocated communication and collaboration in meetings and in teaching. The evaluation method focused on social dynamics, and the goal was on discovering how well a computing environment might function as a proactive “butler” that senses what the users need and then assists them at the right time in the right way. This approach emphasized the intelligence of computing systems over people’s embodied capabilities. Their evaluation built on the collaboration usability analysis (Pinelle, Gutwin, & Greenberg, 2003).

The evaluation of intelligent environments, such as control rooms with complex networked equipment, thus far has been primarily based on the traditional usability and ergonomics emphasis (cf. Savioja, 2014). These evaluations emphasize safety, human well-being, and the attainment of predefined goals. It is understandable that, in production environments, this is a highly feasible approach that conforms to general regulations about work regarding expectations of efficiency. However, when design focuses on private and creative workspaces, a more flexible use of digital resources may lead to better results in terms of work productivity and enjoyment of interaction. In order to achieve these goals, further development of methods and approaches that recognize variation in the users’ needs, as well as differences in the users’ motivations, is needed.

Loke and Robertson (2013) reported a long line of research in movement-oriented interaction design and, on this basis, they formulated a method as presented in their article “Moving and Making Strange” (i.e., moving, sensing, and feeling in order to open up new spaces for design). Central to this method is providing a coherent approach to movement-based interaction design in which movement is considered an input for interaction design. According

to Loke and Robertson, the approach allows for a systematic and principled development of movement-based interaction. The approach operates from three central perspectives, those of the mover, the observer, and the machine. The process of moving and making strange consists of seven phases: (a) investigating movement, (b) inventing and choreographing movement, (c) re-enacting movement, (d) describing and documenting movement, (e) analyzing visually and representing movement, and (f) representing machine input and (g) interpreting moving bodies (Loke & Robertson, 2013, p. 7:11). The moving and making strange approach suits well the design of movement-oriented interactive systems.

Kaasinen et al. (2013) approached intelligent environments from a user-centered perspective and built their approach on the concepts of user expectation, user acceptance, and user experience. They recognized the interplay between the concepts of expectation and experience. On the one hand, experiences are affected by individual expectations, and, on the other hand, experiences can become influential in the formation of future expectations (Kaasinen et al., 2013, p. 12). User acceptance, meanwhile, is defined as the intention to use a certain technology or the actual use of that technology (p. 6). The writers pointed out that the majority of user acceptance studies were first conducted in organizational contexts. User acceptance theories have been used to provide an understanding on how workers adopt new information technologies and on how this information could facilitate adoption processes in the target organization. Since then, the arena of user acceptance studies has widened to accommodate complex interrelating systems and consumer-oriented applications. With these reinforcements, Kaasinen et al. argued that user acceptance studies have incorporated some of the critical variables to benefit the studies on intelligent environments (p. 6).

Kaasinen et al. (2013) also noted that users should be provided with a role as co-crafters of their intelligent environments (p. 3). They argued that, as intelligent technologies become ubiquitous and pervasive, the use of intelligent technologies becomes less optional; rather, smart technologies become part of users' surroundings and daily life. Thus, users should be allowed to participate in the development of these environments because the solutions directly affect their lives (p. 3). Rogers (2006) presented similar ideas and stated that, despite the expected major leaps in technological intelligence and automation, taking the initiative to be creative, constructive, and in control of the interactions within the technological environments is an activity that should belong to the user. Furthermore, technologies could be designed to activate and motivate the user through interactions that creatively, excitedly, and constructively extend what people currently do (Rogers, 2006, p. 406).

Typically, interaction design in intelligent environments is conducted and presented in the form of narratives, such as scenarios (Carroll, 2000), customer journeys, or journey maps (Polaine, Løvlie, & Reason, 2013). These methods omit a wide portion of the actual structures of movements in which people interacting in the technologically mediated environment engage. Choreographic analysis ensures that indirect yet meaningful movements that emerge in the particular local context of use are critically examined.

## METHODS AND RESEARCH DATA

For this study, we expanded the choreographic approach to interaction design method of Parviainen et al., (2013) used in a previous experiment (Poutanen, 2015) in which two videos

presenting a future view of networked technology by the Microsoft Corporation were analyzed. Both videos are called the *Productivity Future Vision*: The 2009 version runs 5 minutes and 46 seconds, and the 2011 version has a length of 6 minutes and 18 seconds. These videos narrate how future information networks could be utilized with ubiquitous interactive technologies, clearly emphasizing the benefits of linked data resources, open access, and powerful information processing. The visions are presented as a sequence of different scenes. Together, these two videos can be interpreted as providing views to a day-in-the-life of the two central characters. The scenarios cover places and situations that characterize smart home, intelligent transportation, and smart office, and merge personal and professional communication.

Our analysis of these videos was conducted with the choreographic analysis method extended with the hermeneutics of the body method. The approach yielded new research data in the form of notes and experiences that were utilized in the analysis. For example, the data included notes about desirable and undesirable characteristics of movement continua, such as intuitive movement sequences, logical visual–haptic couplings of augmented and internal feedback, and kinesthetic coherence. The notes were initially made in a format of a dance diary, which was kept throughout the research process. The dance diary was in itself an open-ended but frequent process of writing entries about ideas and experiences related to different steps of the experiment. Connections between the dance diary and the adopted methods—choreographic analysis and hermeneutics of the body—made the dance diary a central tool for reflection of theory in relation to the research data, which consisted of two videos *Productivity Future Vision* (2009; 2011). The dance diary was also a key process that provided data that allowed documentation and reflection about the hermeneutic process, as experienced by the enacting researcher Olli Poutanen.

## Choreographic Analysis

Choreographic analysis (Parviainen et al., 2013) is an analytic approach that addresses diverse movement dynamics and emphasizes the perspective of an embodied and active user. It enables the assessment of interaction choreographies on various temporal and spatial scales. The approach may be used to detect design flaws and highlight successful choreographic designs related to both individual and intersubjective interactions. Choreographies serve as instruments for shifting the focus of design from the shapes and structures of objects to the activity and intended use of technology. Understanding and expressing the user’s movement continua is a practical way to approach the movement-oriented flow of everyday activities (Parviainen et al., 2013). The choreographic approach addresses the embodied dimensions of experience that can be accessed only by an experiencing body, and choreographic analysis hence recognizes the researcher’s body as a legitimate research instrument (cf. Hoppu, 2005).

In practice, choreographic analysis can be described with a three-level structure. The levels are labeled as *micro*, *local*, and *macro*, although all of the levels are interconnected. The microlevel describes the dynamicity of “acting-sensing bodies and enactive minds” (Parviainen et al., 2013, p. 110) and the focus is directed toward the subtleties and habitations of the user’s muscular activity. The spatial focus of microlevel choreographies is the kinesphere, that is, the space within the body’s reach (Parviainen et al., 2013, pp.110–111; also Laban, 1963, p. 85). Different ways of touching, looking, twisting, squeezing, pushing, turning, and so on, are examples of micromovements that are considered in the analysis. These individual micromovements are not



studied in isolation but as constituents of micromovement sequences. These movement sequences form the units of analysis for this study, and they are examined in relation to the kinesthetic experience of conducting the movement continua.

Local-level analysis concentrates on the relation between the engaged performer and the “intentional, environment-oriented and social aspects of interaction” (Parviainen et al., 2013, pp.110–111). A local-level analysis aims at clarifying how the flow of the movement continua fits into the user’s situation and addresses usability-related questions, such as the intuitive and engaging character of the interactions. Macrolevel analysis addresses the “socio-cultural effects of the design choices” (Parviainen et al., 2013, p.110). This is a systems-level perspective that helps in addressing the question of choreographic sustainability. Macrolevel analysis operates on a global scale, addressing phenomena both in geographical and virtual space (Parviainen et al., 2013, pp.110–111).

Microsoft’s *Productivity Future Visions* (2009, 2011) expectedly presented an abundance of visions related to computation, on-demand processing and visualization of data, smart supply chain management tools, and telepresence meeting solutions, all relevant in both local-level and macrolevel choreography analyses. However, because the kinesthetic analysis is the main focus in this study, the local-level and macrolevel perspectives were not aspects of our analysis. More information on local-level analysis can be found in the previous study (Poutanen, 2015, pp. 44–53).

## **Hermeneutics of the Body**

Hermeneutics of the body is a method developed by Petri Hoppu (2005) building primarily on the thinking of Hans-Georg Gadamer (1960/1975). It presents a perspective of science that connects research and dancing. In hermeneutic analysis, the researcher is in contact with his/her object of research (in Gadamer’s work, primarily texts) and, as the researcher gains new insights concerning the object, his/her perceptions and expectations change. The basic idea of hermeneutics can be abstracted as a spiral representing a process that deepens the researcher’s knowledge of the research object (Hoppu, 2005, p.107). With the felt dimensions of movement as the object of research, the researcher’s own body and the memories carried by the body can be seen as primary resources of the study (Sklar, 2000, p. 71).

This entire process of interaction can be regarded as an extension of the human empathic capacity, which, according to de Waal (2008, p. 281), enables a person to access and assess another person’s emotional state and the reasons for the state, and to adopt the other person’s perspective. According to philosopher Edith Stein (1917/1989, p. 20), adopting the other person’s perspective is a special way of “knowing within others,” which differs from conceptual knowledge. The latter knowledge is typically based on verbal communication, whereas the former is that which can be grasped primarily through the experienced, embodied acts with the other. Stein’s view was elaborated by Parviainen (2003, pp. 157–162), who referred to kinesthetic empathy as a key feature in understanding another person’s nonverbal kinesthetic experiences and in acquiring knowledge of his/her movement. When one perceives another person’s movements, one does not merely perceive bodily expressions, but also the living experiences of those movements, though not primordially. Moreover, Dee Reynolds and Matthew Reason (2012) argued that kinesthetic empathy is not limited to human interaction, but it also includes objects and spaces. An object may merge with its human counterpart through an empathic act, of which riding a bike is an example, and a space may have a strong, embodied impact, such as on a person who enters a large room.

Typically, researchers have paid little attention to the embodiment of research, despite the fact that corporeality forms an essential part of social reality. According to Thomas (2003, p. 77), little discussion has explored the embodiment of research activities, that is, through practices such as observation, interpretation and/or analysis, and, more importantly, the influence of these on the experiences of both the researcher and the researched (see also Hoppu, 2005, p. 107). However, the body is clearly a means to acquire knowledge of the movement, and—through understanding “qualitative and associative nuances” of the movement—the body provides the researcher with a language to express this knowledge (Sklar, 2000, p. 75). Therefore, the moving and experiencing body is not only a phenomenon under investigation but also an evolving reflexive process of inquiry involving the researcher as a living subject with his/her activities examined from the perspective of embodiment in this approach.

Traditionally, the hermeneutic analysis begins in the field, where a researcher meets practice. During this phase, s/he also articulates his/her experiences in text. In our research, the fieldwork phase refers to the learning and performing a choreography based on the micromovements performed in the Microsoft videos. Here, *choreography* is seen as a process of both producing and reproducing embodied knowledge—a way of articulating and structuring movement as well as learning and conveying it through empathic acts. In other words, choreography is not limited to something that is merely observed, but it is something that may become a part of a researcher’s body. This resembles Nonaka and Takeuchi’s (1995, p. 64) mode of socialization, where tacit knowledge is conveyed from one person to other people through interaction or observation. Their model has been criticized for being limited (Gourlay, 2006). Nevertheless, adopting tacit knowledge into one’s body is regarded as a significant facet for developing an understanding of the body-movement phenomenon under investigation.

Embodied knowledge needs to be made explicit for people to become aware of it. What Nonaka and Takeuchi (1995, p. 65) called externalization is also a central element of research. In our study externalization encompassed (a) learning to perform the movements, including the continua of body postures, individual limb movements, and sensuous foci reaching out to the surrounding space, (b) understanding meanings of interactions, and (c) interpreting the nuances relating to the microlevel choreographies. In the overall hermeneutic process, embodied knowledge was externalized and documented in active writing, which implies that the researcher constantly compared what he had written regarding evolving experiences, feelings, and skills, and iteratively works towards a deeper understanding of what was examined (Hoppu, 2005, p. 109). The hermeneutic process intertwines human embodiment, its experience, and its interpretation (Hoppu, 2005, p. 107).

## **The Research Procedure**

The research procedure of the micromovement interactions was conducted in five steps: (a) extracting, (b) reorganizing, (c) performing, (d) dance writing, and (e) analyzing.

During the extraction step, the main elements of the choreographies were extracted as separate movements from *Productivity Future Visions* videos (2009; 2011). A total of 112 individual screenshots depicting individual micromovements were taken and arranged. The screenshots were first arranged into a sequential continuum from a start of an action to its completion. The screenshots were organized on a computer screen so that each movement continuum was organized on a vertical axis, resulting in separate image clusters. Within each

image cluster, the first micromovement was set in the uppermost part of the screen. Screenshot clusters representing different scenarios, movement continua, and use contexts were aligned horizontally in rows. This approach provided a wide visual view of the material of the choreography as a whole and thus provided a good starting point for the reorganization of the data.

In the reorganizing step, the previous screenshot clusters were reorganized into three clusters corresponding to the body position of the user during interaction, namely the sitting position, standing position, and walking. The reason for reordering the formerly mixed order was to enhance the flow of activities that composed the choreography, thereby allowing a movement progression from the performance components (i.e., rehearsal and “dancing”) to analysis. Based on body postures, the enactment of the choreography logically flowed through all relevant movement continua first from sitting, proceeding to interactions in a standing position, and moving on from standing to walking, in line with the original interaction.

In the performance step, the enacting researcher performed the rearranged choreography through the chunked movement flows. This performing was supported by a process known as dance writing, meaning developing a script of the micromovements to be performed as well as writing down observations that emerged during the performing. The performing and dance writing steps were carried out alternately. In the rehearsal of the movement continua, the focus of dance writing was on the technical reproduction of the movement: the correctness of the body alignment and executing right micromovements in a right order. Once the choreography was internalized by the researcher, the dance performance process was initiated, with the focus shifting to assessing the bodily experience of the movement. Dancing the movements was thus the premise for creating embodied understanding of interaction and engaging a state of critical thinking where the nuances of interaction could unfold. At this point, a dance diary was used to explicate emerging ideas and interpretations of the kinesthetic experience of human-technology interaction.

Figure 1 illustrates how the movements were performed without representations of technology to better focus on the movements and kinesthetic experience. The enacting researcher performed all the micromovements involved in the specified activity, including the gazing, and imagined the use context that involved the devices, the physical architectonic space and furniture, and the information content around him. This was important because, without keeping the use context in mind, the analysis would only have represented the pleurability of a certain movement sequence. The researcher’s ability to differentiate transitions from one device to another as well as the spatial organization of the choreography allowed him, for instance, to locate discontinuities in the movement flow and reflect the cause for dysfunction in the suggested micromovement continuum for a specific interaction.

The researcher conducted the choreographed dance within a 7-day timespan of intensive engagement with the movements. The dancing cycle consisted of morning and evening sessions. Writing about the dancing experience was conducted daily within the two sessions, resulting in an iterative writing process typical of the hermeneutic process. The choreography was danced five times a row in each session. A dance diary, written by the enacting researcher immediately after the session, was used for documenting the ideas and findings that emerged during and after the dancing. Diary entries were written in a nonstructured manner. As the writings based on the sessions started to accumulate, several interests and themes started to shape. The practice of writing helped the enacting researcher to explicate kinesthetic sensations and become aware of specific nuances in the choreography. Performing and writing thus constituted a reciprocal process.



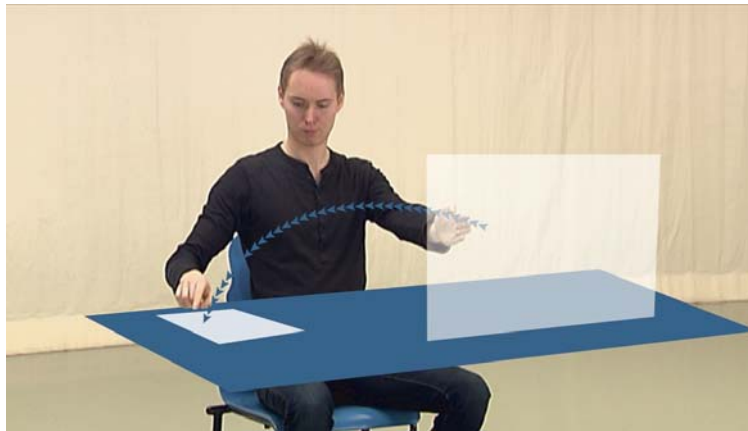
**Figure 1.** In the movement continuum example above, the user copies information from one device to another with gesture commands without actually employing the technology, thus reflecting a perspective of movement experience of using the technology within the imagined use context. The enacting researcher holds his left hand in a pointing position and enacts a sequence in which he directs imaginary information content on a computer screen. In using his other hand, the user drags the content from a computer to a tablet device. This enactment also demonstrates how the micromovement of dragging is part of a continuous flow of movement in the overall choreography that progressed seamlessly through the various actions conducted with the imaginary technology surrounding the performer.

Altogether, the enacting researcher performed the choreography 70 times during the entire enacting period, which means a total of 7840 micromovements performed in the cumulative choreography. One round of performing the full choreography took approximately 2 minutes 30 seconds; thus, the entire study totaled 175 minutes of active dancing, traversing all the studied movements. Going through movements to this extent is not essential for learning an advanced skill, but it nevertheless allows for the attainment of such repeated embodied experience of the studied choreographies that functions as a foundation for drawing conclusions about the kinesthetic experience and about the experienced effectiveness of the performed actions. At the end of the performing and dance writing steps, a final performance was documented on video with three cameras in a television studio. The choreography included the 112 micromovements, flowing from sitting to standing to moving, resulting in a total of 150 seconds of performed choreography, that is, the dance. The video shows the enacting researcher's body in a quasi-empty studio. The space was furnished with only a chair for presenting movements in a sitting position.

Because the performances were created without physically employing the technologies under investigation, the dance rendered visible the movements that were obscured by the overwhelming visual richness of the original video material that utilized special effects extensively. Thus, the visual documentation of the dance underscored the relationship of reciprocal influence between and among the technological designs and interactive interfaces and a user's body and his/her movement on the other. The visual performance was, however, only a part of the process. Addressing the experience of performing the movements as if being immersed in the use context formed another challenge.

The research process concluded with the analysis. It would be erroneous to state that it was the last phase, particularly when performance, reflection, and analysis occurred in a hermeneutic loop throughout the study. The analysis process, therefore, unfolded as a reflective and analytical dialogue within the construction of the choreography. In this dialogue, attention was paid to the microlevel phenomena through the definition of movement continua (Poutanen,

2015, pp. 38–53). The analytical focus was on the kinesthetic experience on one hand, and on technology design on the other. The notes compiled in the dance diary created by the enacting researcher regarding the microlevel choreographies were grouped and the groups labeled by the enacting researcher during and slightly after the active performing of the choreography. The focus was on discovering the desirable and undesirable characteristics of the movement continua, such as intuitive movement sequences, logical visual–haptic couplings of augmented and internal feedback, and kinesthetic coherence. An example of the imaginary technology and the gestural trajectory are depicted in Figure 2 to illustrate how the enacting researcher conceived the technology in his immediate surroundings in performing the interaction.



**Figure 2.** A visualization depicting the imaginary technology (i.e., a tablet and a desktop computer) superimposed onto a frame from the movement continuum used by the enacting researcher in performing a sequence. These visualizations were not part of the performance but are added here to show how the enacting researcher was imagining the technologies.

## FINDINGS

The process of reorganizing the micromovements and the iterative processes of rehearsing/dancing and dance writing yielded discoveries in multiple areas. Most importantly, the enactment generated insight into the kinesthetic experience and usability of technologies proposed in the Microsoft visions as well as into generic considerations of how particular technology artifacts constrain, guide, and support movement, positioning, posture, orientation, and sensuous foci. The visual–tactile continua in time and space were found to have a strong significance in regard to the experience of interaction. This outcome points to the importance of how the orchestration of human–computer interaction within a network of heterogeneous, interconnected devices could be made to enhance the user’s kinesthetic experience.

The technological designs in both *Productivity Future Vision* (2009, 2011) productions are based on five distinct technological artifacts: mobile resources, tabletop screens, smart walls, wearable technologies (glasses and wristwatch), and small-sized smart objects. All these intelligent interactive elements impact the user’s movement, position in space, posture, and sensuous focus, among other embodied experiences. In the *Productivity Future Vision* videos, many of the artifacts employed have specific vocabularies and typical movement continua for

interaction, both individually and when combined with other types of artifacts. One key finding of our research was that combining various artifacts creates the setting for choreographies. Understanding the different choreographic possibilities related to certain technologies and their collaborative use can thus facilitate interaction design in specific use contexts.

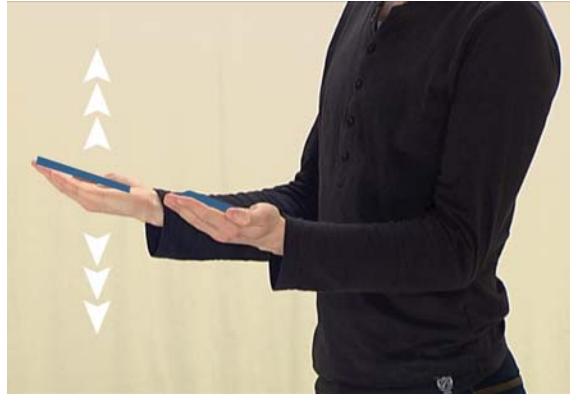
Kinesthetically, the enacting researcher experienced the use of small handheld devices as unpleasant and restricting. The experience probably was compounded by the lack of any actual reference point in the enacting researcher's hand. Larger screens, however, enabled the utilization of broader movement trajectories, allowing the activation of larger areas in the body. The enacting researcher considered these movements more natural and pleasurable. This outcome also could be a question of personal preferences. The smartphone and tablet-size interfaces performed well in situations in which the actual data manipulation was realized with embedded information resources, such as on large wall screens or on the top of a table. The smart handheld devices were experienced as performing the best when operated within the ecology of resources, such as screens shared by connected computing processes (see also Poutanen, 2015, pp. 55–59).

The tactile–visual input–output loops between the user and the technological system can be considered a basic organizing principle of human–computer interaction in the *Productivity Future Vision* (2009, 2011). The user's body during the interaction seemed to be related to the spatial–temporal progression of visual foci in space in ongoing interaction. The result of this aspect of the analysis suggests that dynamic relations between the visual and tactile foci have a comprehensive influence on the user's body during the interaction, which should be further examined. A key finding was related to the role of the user's sight in interaction; when his/her gaze was traveling across multiple screens provided by a device network, it seemed to have the potential to enable choreographies that activate the user's body, for instance, enhance shifts between body postures and alignment in space, as a reaction to relocation of visually displayed information in surrounding space. We suggest that designs that assist in shifting visual focus can be intentionally designed to enhance smooth changes in body alignment and posture. On the contrary, superimposed visual and tactile foci, especially when extended over time, can lead to stagnant and unpleasant kinesthetic experiences (see also Poutanen, 2015, pp. 58–59).

## **Kinesthetic Pleasure**

Dance reflections proved to be valuable in recognizing the challenges within the micromovement sequences and, in contrast, finding insightfully designed choreographies that resulted in pleasing kinesthetic experiences. First indications of successful choreographies arose at the beginning of the dance practice. The enacting researcher recognized that it was easy and quick to internalize a particular interaction into dance. Dancing also evoked personal experiences of the pleasurability of particular movement continua. In particular, tapping as a method for drawing data from the device was reported as fun by the enacting researcher. In the dance diary, the enacting researcher described the experience as resembling the act of tapping a floating object so that it submerges and resurfaces with a popping motion.

The kinesthetic feel of the micromovement choreography of a map application that zoomed in response to vertical level alterations of the hand-held smartphone screen also was experienced as pleasurable. The motion would enlarge the map when lifting the device up and to shrink the map when moving the device down (see Figure 3). This movement was among the favorite movement sequences reported by the enacting researcher. The application enabled dynamic exploration of a



**Figure 3.** Example of using level-alterations in scaling the content to a desired level of detail on a relatively small screen; moving the device upward zoomed in and downward zoomed out.

map on a small-screen device through use of two hands. It recognized sweeps and finger-based zoom commands (two or three fingers) without compromising the usability of the application.

This particular use feature also provided a surprise for the enacting researcher. The visual image of the use situation on video was not appealing at first. However, the related somatic experience of the micromovement choreography of the interaction was experienced as pleasing. Thus, it can be stated that the embodiment of the choreography changed the enacting researcher's preconception of the use experience of this particular interaction. Enacting also revealed that it is not enough to design good individual movements in isolation: It is necessary to think through how the complete interaction choreography flows as a movement sequence. A clever micromovement idea can be lost within a clumsy movement sequence.

Based on the experience of the enacting researcher, some of the movement combinations required uncomfortable body postures and the suggested micromovement sequences resulted in unnatural bodily positions. For example, the interaction was experienced as unpleasant when the researcher had to stretch his arms towards the side and perform a converging movement. The enacting researcher, a young healthy male, experienced these movements as straining. However, working through the complete dance choreography sensitized the enacting researcher to the differences and similarities across the kinesthetic experience of the movement sequences. Thus, some of movement continua were experienced as complex and physically demanding while others were free flowing. Some movement sequences were experienced as rigid, and their rigidity was highlighted by the surrounding fluent movement sequences. Thus it is possible that technological interactions presented in video productions as smooth and pleasing could, in reality, not be the case. Analysis of technology use through reenactment is therefore a more truthful or accurate means for assessing the quality of experience than is watching a mediated use when the kinesthetic experience is the focus of interest.

### **Usability and Embodied Engagement**

In the *Productivity Future Vision* (2009, 2011) videos, it was suggested that the envisioned interactions enable the user to accomplish technological interactions smoothly. The visions presented rich variations in choreographic strategies that seem to be created in order to avoid interactions with strictly logical means. Usability is taken into account through the optimization

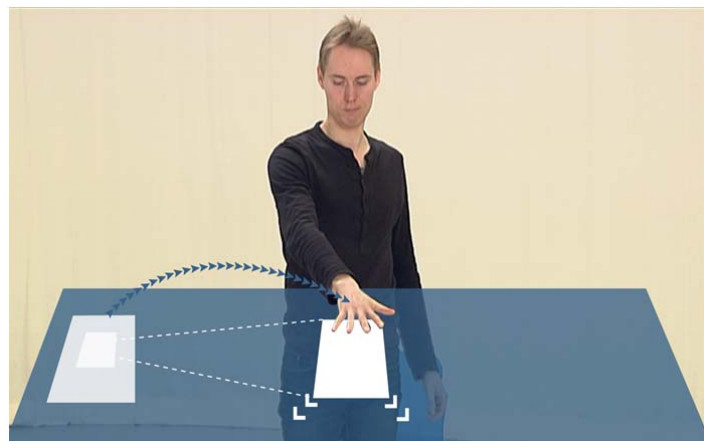
of user–system behavior by minimizing the time, effort, and errors by users trying to attain their goals (cf. Nielsen, 1993). Some of the usability issues were easy to identify through the choreographic approach. For example, it was apparent that some of the micromovement sequences were too complex, exemplified by the difficulty in internalizing and performing the sequences. This resulted in extra movements, as compared to other interaction choreographies with a similar intent. By making the usability issues explicit between homologous choreographies, it was possible to locate inconsistencies in the overall choreographic vocabulary.

However, there were some examples of intuitive choreographies that could be figured out just by using the technologies, that is, “learning the possibility of drag and drop interaction can also be learned by accident” (Dance diary excerpt). Usability was also reported as a user-driven recombination of visual displays in space, in that the “wider table-surface-computer provides a larger screen that supports extending the illustration into a form that supports [the activity of the user]” (Dance diary excerpt). A figure representing the transmission of information from one device to another between a table surface computer and a tablet computer device is presented in Figure 4.

In sum, it could be concluded that usability was assessed by the enacting researcher in terms of how a technological system supported the body’s ability to learn, remember, and become skillful in controlling networked resources in the intelligent environment. The researcher’s personal learning process through choreographed reenactments of the micromovements provided a benchmark on how that can be achieved.

### Limits of the Choreographic Approach

The choreographic approach had limitations in instances in which particular information perceptualizations had to be considered. *Productivity Future Vision* (2009, 2011) presented a number of interactions in which the content at the edge of the screen seemingly disappeared from



**Figure 4.** Example of how devices network spontaneously in *Productivity Future Vision* and how the advantages of different forms can be seized; in this figure the surface of a large screen has been taken into use in scaling up content in order to create a more appropriate visual representation concerning the user’s task at hand.



a device and reappeared on another. Because no augmentations or props of any kind were used when reenacting these specific choreographies, interactions in the video data had to be consciously performed in keeping the original context in mind. The problematic character of these events, however, unfolded when the nature of that particular movement continuum was developed into embodied knowledge of the enacting researcher, and thus an active component of the reflection that emerged during the performance. In confronting these types of situations, it is important that the researcher observe closely in the original video the relative position of the devices or whether the target screen is situated behind the sending screen, on top of it, or somewhere else. Moreover, a choreographic analysis is based on subjective experience and the quality of the analysis corresponds with the researcher's experience and skills. The approach can be considered as artistic research on technology. Further development and adapting the method to a more systematic evaluation of human-computer interaction is needed.

Some usability issues are more challenging to assess through the choreographic approach, however, such as movements that required painstaking care with body positioning. For example, while a menu interface required the user to control his/her hand accurately in an exact position, the danced performance was unable to recreate the role of the physical surfaces in providing physical support for performing the movements accurately. Such realities make the enactment insufficient for providing, for instance, tactile and haptic feedback on the devices with which the user directly interacts.

The choreographic approach conducted with only one person enacting the choreography also overlooks the social aspects of the situations with technology where interaction between different users plays a role. This study was nevertheless an experiment with the goal of developing and understanding what would happen if technology-design critique was based on experiences occurring in continuous movement of a single user in an environment with networked devices, such as visual displays with touch screen interfaces. The study concentrated on the experience of movement and it was realized in a way that explicitly moved technology out of the way of the moving body.

Finally, this research raises concerns regarding whether data can be gathered and analyzed from only single levels of the choreographic approach. It became apparent in our analysis that local-level choreography, that is, collaborative use, also is needed in when investigating the productivity of an activity. For instance, when people use data across devices and work with it collaboratively, the social choreography is heavily influenced by the way in which the users are allowed to make changes to the data on the fly. In addition, collaborative choreographies are closely connected to the perceptual qualities of technology. Further research is needed on the development of a multiple-dancer choreography for learning about the multiactor movement characteristics for investigating the collaborative kinesthetic experience in interactive technology environments. This research approach also would address how it feels to perform particular kinds of movements while others are observing.

## DISCUSSION

When performing a well-rehearsed choreography, in this case, based on movement extracted from a fictional representation of human-computer interaction, the enacting researcher is not responding to any new information that might appear on the imaginary screens. Hence, the

technique is inward-looking in that it focuses on the embodied experience of using one's body to control and attend to multiple technology channels in imaginary, ubiquitous environments rather than on the human-computer interaction happening around the body. Thus, the discovery of new affordances, that is to say, new ways of engaging with technology, is not based on feedback from external-to-body devices but rather from the performing and experiencing body.

The choreographic approach directs attention toward personal engagement in the activities of reorganizing, performing, and writing about the choreography, thus fostering the development of a detailed understanding of the kinesthetic experience of the interaction choreographies. As a result, the approach promotes the development of researcher sensitivity, especially to the kinesthetic experience of a movement continuum in which the arrangement of trajectories between visual-tactile foci influences the body posture, alignment, and reach of movement.

Considering the differences between the represented architectonic space in the video representation and the real physical surroundings where the choreography is performed, it may be surprising that the choreographies also facilitate the development of understanding about the interplay between the user and physical contexts of an interaction. The process of enactment had to be carried out in a way that it constructs the context and thus helps the enacting researcher to perform the movements while taking into account the missing elements, such as the devices and characteristics of the physical space in the original use context. The combination of watching the original human-computer interactions and dancing the choreography made it possible to assimilate the experiential and the contextual into an embodied understanding. The approach emphasizes the importance of understanding the embodied mind for the quality of interaction design, and it seems especially well suited for the study of multichannel experiences. As a result, investigating complex interactions through a choreographic approach is neither constrained nor enabled by knowledge or experience of particular technologies. However, the process is fully driven by the development of the choreography that makes visible the demands and delights that the studied design context sets for the experiencing body.

Contemporary visions of intelligent environments are dominated by visual inputs. What if we researchers and designers started to think about movement as an input to interaction design or even as a major factor for the user experience? The development and study of interaction choreographies provides an alternative way to consider users' preferences in choosing a channel, thereby opening up opportunities to discover how intelligent environments could be improved to provide alternative choices for a diversity of users. In the context of software design, developers typically talk in terms of workflow. This is conceptualized as sequences of tasks leading up to an attained goal. The process of embodying choreographic principles to tap into the body's knowledge requires time, effort, and creative approaches. However, such investments may be beneficial by increasing opportunities for novel design that addresses better the kinesthetic experience.

The studied videos described people interacting with envisioned future technologies. The research data restricted the choreographic analysis solely to the kinds of interactions that were depicted in the original videos. However, we see that the choreographic analysis can also be used methodically without such detailed examples. For instance, researchers could start from a particular technical possibility, and then pursue investigating the mutual interplay between device networking, technological forms, adaptable spaces, and/or the user's capacity to move application controls and data across present visual displays. This would allow a greater role and flexibility for embodied improvisation through which novel interaction qualities can emerge spontaneously.

The number of ad hoc networks created by various kinds of devices is rapidly increasing. This creates abundant possibilities for combining and recombining microchoreographic continua based on the concept of adaptable technology. It seems a new era has dawned, one in which users have a multitude of possible channels to “resource” (see Ylirisku, Buur, & Revsbæk, 2016a, 2016b). This change may also provide new opportunities for users to choose, develop, and implement preferred personal interaction choreographies, in other words, to engage in an idiosyncratic process of body-making and meaning-making (see Sklar, 2000, p. 74).

The technological contexts presented in the *Productivity Future Vision* (2009, 2011) videos cannot be accessed; they exist only as visual stories. The depicted technologies and interactions could, however, be projected into a physical setting where an enacting researcher could adapt the choreographic approach with spatially imagined displays, surfaces, and devices. Because the enactment of a choreography as research poses minimal requirements for the physical and technological environments, the ability to learn about the micromovements may prove to be a useful and versatile skill for interaction designers. In line with interaction design patterns in graphical user interfaces, it is feasible to expect that choreographic design patterns for intelligent environments may become commonplace in the future.

## CONCLUSIONS

This paper described a choreographic approach to interaction design and introduced a procedure to extract micromovement continua, reorganize movement material into a practicable choreography, conduct first-person enactment of that choreography, and document the analysis. The procedure built on the choreographic approach to interaction design (Parviainen et al., 2013) and extended it by providing an example of how micromovement analysis can be conducted in practice. The choreographic analysis was strengthened with the hermeneutics of the body approach (Hoppu, 2005). The extended method allows operationalizing first-person enactment and performing movement continua related to the human–computer interactions under scrutiny.

The extended choreographic approach for interaction design method starts with documenting movement continua present in human–computer interaction. The material under investigation also can be selected from established technology visions, as was done in the experiment (Poutanen, 2015) analyzed in this study. The movement continua can be video recorded in real use context, or one can design animated situations or document-improvised interactions in a mock-up setting. The key criterion in drawing on video sources is that video depiction presents all individual movements that are constitutive to the intended human–computer interaction. Based on the video representations of specific human–computer interactions, the movement continua are then reorganized to form a coherent choreography that can be rehearsed and enacted efficiently. The reorganization can be carried out with the help of a movement sequence table that is based on screen shots from the video. Screen shots should present understandably and uninterrupted the continua of the represented user’s limbs and changes in body alignment and posture and differentiate between the micromovements constitutive to interaction. The resulting choreography and the use context are then realized through rehearsing the choreography, keeping the use context in mind.

The use context should somehow be present in the movement sequence table so that the images captured from the video representation of the target human–computer interaction

serve both rehearsing and embodying information about the use context. Thorough analysis is possible when the choreography is being performed with the use context in mind. Ideally, performing through dance-like movement helps the researcher to organize ideas related both to the experienced movement and to the imagined, technologically augmented space. Reporting the kinesthetic experience related to micromovement continua can be done through writing a dance diary. Expressions of the experiences become more explicit in the course of hermeneutic process that, in this experiment, included rehearsing movement sequences and use contexts with the image movement sequence table and looking at the video excerpts from the original interaction data. Results can be reported as textual descriptions and/or video documentation of the practices and procedures of enacting and commenting on the experience related to the studied movement continua.

The evaluations of intelligent environments have typically concerned safety, human well-being, and the attainment of predefined goals. Choreographic analysis through the hermeneutics of the body approach sheds light on how multiple networked artifacts in ubiquitous computing settings influence the movements and embodied experiences of the user. The choreographic and hermeneutic analyses in this study were based on research data that consisted of futuristic technological visions of interactions within user-centered, intelligent environments. The visions were crafted thoughtfully. Nevertheless, the envisioned interactions included interactions that did not fit well within the movement continuum that they were designed to be part of. Although videos can offer an illusion of smoothness, naturalness, and embodied qualities of interaction, the moving body provides the ultimate reference for human experience of movement.

The extended choreographic approach to interaction design shares many similar features with the moving-and-making-strange approach developed by Loke and Robertson (2013). Both may contain the elements of investigating and choreographing the movement, and they also may include inventing and choreographing movement. Also, visual analysis and representation of movements are applied in both approaches. The major methodological premise for both approaches is the reenactment of movement. This characteristic connects the two approaches methodically and makes them mutually constructive. In future work, this connection should be analyzed more deeply. The choreographic approach to interaction design could benefit from the adoption of an approach similar to the three perspectives—the mover, the observer, and the machine—introduced in the moving-and-making-strange approach. This would enable the choreographic approach to mature as a tool for the design of intelligent environments.

This study focused on a microlevel analysis (Parviainen et al., 2013) that proved useful for depicting the felt qualities in sequences of micromovement interactions. A description and discussion of local-level and macrolevel analyses were not in the scope of this study. However, ideally, microlevel, local-level, and macrolevel choreographic analyses would be applied together. Combined analysis of these interrelated analysis levels remains to be addressed in future studies.

The introduction of new contextual services to be consumed and experienced in increasingly intelligent urban spaces, transportation services, educational facilities, and homes will impose requirements on the methods and methodologies that guide the development of everyday environments in a user-centered, movement-oriented manner. A choreographic approach to interaction design that is extended with the hermeneutics of the body method has the potential to mature into a useful tool, mindset, and method for interaction designers who design intelligent environments.

## IMPLICATIONS FOR THEORY AND APPLICATION

This study explored what would happen if technology-design critique was based on experiences that explicitly moved technology out of the way of the moving body. While the study is an initial exploration, it emphasizes the value of taking the kinesthetic experience (comprising the felt dimensions of movement and body and the memories and expectations carried by the body) as the starting point for developing and evaluating interactions with technology. The approach is gaining relevance in the context of design of augmented and virtual reality environments, which provide designers with open-ended possibilities for creating new kinds of interaction choreographies. It is also useful for the consideration of how people may combine and recombine microchoreographic continua with available adaptable and networked technologies in intelligent environments. Theoretically the work opens up for the development and study of new kinds of design patterns and patterns of choreographies aimed for kinesthetic appeal.

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### Authors' Note

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All correspondence should be addressed to  
 Olli Poutanen  
 Aalto University  
 Hämeentie 135 C  
 00076 Helsinki, Finland  
 olli.poutanen@aalto.fi

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