Human-Technology Choreographies: re-thinking body, movement and space in interaction design

A NordiCHI 2014 Workshop

Foreword

Human-Technology Choreographies: re-thinking body, movement and space in interaction design is a workshop that was held on the 27th of October 2014, Helsinki, Finland, as a part of NordiCHI 2014, the 8th Nordic Conference on Human-Computer Interaction.

In interaction design, we often tend to focus on objects rather than the movements relating to interacting with them. Even when we do consider movements, we tend to emphasize their instrumental value, i.e., how they have direct effect on the functions of technology. The aim of the workshop was to start re-thinking the role of movement in the design and use of technology, and explore the ways of using movements as both conceptual and practical basis for interaction design.

The term choreography refers to the meaningful continuums of movement we experience in our interaction with technology. Each technological design manifests choreographies of varying scopes. Human-technology choreographies are implied in subtle finger movements as well as in the movement of crowds in public spaces. A choreographic orientation brings forth all the more opportunities and options that interaction designers possess for defining movements and movement-qualities required in interacting with different devices. Human movement is never a mere structure that could be handled without also affecting the inherent meanings it embodies.

The workshop gathered together researchers and practitioners whose work is related to human movements in interaction design. This proceedings publication of the workshop includes eight peer-reviewed short papers that acknowledge movement as a basic constituent of thought and design.

Acknowledgements

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Abstract
The way we interact with computers at work has remained largely the same for four decades. This paper discusses the need to find alternatives to WIMP interaction in serious applications, and presents bodily interaction as a design opportunity to enhance users' physical health, user experience and quality of work.

Author Keywords
Bodily interaction; interaction techniques; serious applications

ACM Classification Keywords
H.5.2 User Interfaces

Introduction
We live in a world of increasingly fast flows of people, artefacts and information, yet our bodies are more immobile than ever. The ways in which people work, travel and relax in the industrialised world are characterised by *sedentary behaviour*; that is, doing activities with low energy expenditure while sitting or lying down [11].

Recent studies have associated sedentary behaviour with health risks such as diabetes and heart disease [14]. Furthermore, it has been found that even if people exercise after work, it may not be enough to compensate for the harm done to their bodies during long hours of immobility [10]. In other words, it is not enough to exercise after spending a day in front of a computer; it is the sedentary activity itself that needs to be transformed.

With this in mind, several alternatives have been suggested for using computers at work. One of them is to use a desk with adjustable height, and to stand in front of the computer for at least a few hours per day instead of sitting. Other suggestions include a treadmill desk [13] that requires a user to walk at a slow pace while they work, and a pedal exerciser [2] that can be fitted under a computer desk.

These alternatives are enough to break prolonged hours of sedentary computer use at work. Nevertheless, none of them addresses the root problem: the technology we use at work has not been designed to make us move. If anything, it has been designed to minimise all physical effort. The prevailing WIMP interaction requires users to keep still, and limits their physical expression to small, repetitive movements of hands and fingers. Even the technology we call "mobile" is not really about making users mobile, but allowing them to remain immobile in different places [5].

A treadmill desk and a pedal exerciser are examples of simple solutions that do not interfere with the current way of interacting with computers. At the same time, neither walking nor pedalling is related to computer uses or work tasks in any way. As such, they are mere add-ons designed to counteract the physical harm, but without considering how bodily interaction could change the way we work with computers.

Another alternative would be to redesign the way we interact with computers. Technically, recent advances in processing power, small sensors for motion detection and wireless networks have made it possible to develop new bodily interaction techniques that allow users to use their whole body for interacting with computers. Examples of such interaction techniques can be found in games [4], sports [8] and physical rehabilitation [6].

Yet the situation is quite different when it comes to serious applications such as productive or communication software that are routinely used at work every day. While *what* can be done with such applications has developed rapidly, *how* it can be done has remained surprisingly similar for four decades.

Design viewpoints

Bodily interaction as such is no more natural or intuitive than WIMP interaction unless it is designed to be so, and as an interaction modality it certainly has its own usability challenges. In addition, studies with treadmill and pedal desks have shown that introducing physical activity into the work context raises concerns about its fit with the expectations, preferences and norms of the workplace.

The traditional viewpoints of usability and fit to context, however, are not necessarily the best starting points when designing bodily interaction for serious applications. The usability of bodily interaction, for example, is not merely a representational matter. Designers should thus rather focus on the situational and embodied aspects of interaction to understand better what can be done with bodily interaction [9]. In addition, to explore the full range of possibilities of bodily interaction, designers need to be ready to break away from existing conventions. Any bodily interaction technique is likely to require some changes to the work practice, which will not necessarily be a problem if the perceived benefits are sufficiently significant. Therefore, instead of trying to find the best fit with current work contexts, designers should be prepared to challenge them.

Designing bodily interaction for serious applications would require physical movement to be regarded as an integral part of human-computer interaction. Furthermore, while physical health benefits can be one motivation for designing bodily interaction techniques, there are other, equally interesting design opportunities. These include exploring how physical movement can change the way we feel and how we express ourselves when working with computers, and how all this could affect both our experience of work and the quality of work.

1) Physical health
In WIMP interaction, the relationship between movement and health is discussed mainly in terms of how to limit the damages to a user's health from prolonged use. Bodily interaction, on the other hand, has a potential to integrate physical and mental activities in ways that could promote physical health and make computer users the fittest of all workers. In design, this requires considering how physically demanding interaction can be as well as the quality and variety of movement.

In WIMP interaction, the variety of movement tends to be very low and restricted to the hands and fingers. Bodily interaction gives opportunities for designing more varied interaction techniques that involve the whole body or offer alternative ways of interaction for different tasks.

2) User experience
Human movement can be studied objectively, but also in terms of *lived body* [7]; that is, how people experience the world through their bodily actions. The way people move is connected to how they feel and what they experience. Thus, it is not surprising that while WIMP interaction has its merits in terms of efficiency, the same cannot be said about user experience. Anyone who works regularly at a computer knows how tired and dissatisfied one can feel after a long day of sitting and clicking keys and buttons. Nevertheless, there is no reason why interacting with serious applications could not be a more satisfying experience, or why video conferencing has to feel like "sitting and chatting through a small window at a prison's visiting center" [3].

Through bodily interaction, it is possible to make interacting with computers more expressive, engaging, fun and stimulating. This, in turn, could affect how people experience their work tasks, leading to more interesting, motivating and fulfilling work experiences.

3) Quality of work
Research in embodied cognition has shown that directing people to move physically in certain ways can improve comprehension, learning and problem solving [1]. Similar connections have also been found between creativity and movement: [12], for example, found that after performing fluid movement (as opposed to angular movement), people improved at generating creative ideas.

While more research is needed about how bodily interaction can affect the process and results of work tasks, the existing studies suggest that besides improving a user's physical health and user experience, bodily interaction could also have a positive effect on their quality of work.

Conclusion

The opportunities of bodily interaction have not yet been widely explored in the context of serious applications such as productivity and communication software. Understanding the full potential of bodily interaction in serious applications requires going beyond the traditional viewpoints of usability and fit to context. This paper suggests three viewpoints for further research and design efforts on the topic: how bodily interaction can improve physical health, user experience and quality of work.

References

[1] Antle, A.N. Research opportunities: Embodied child-computer interaction. *International Journal of Child-Computer Interaction 1*, 1 (2013), 30-36.

[2] FitnessCubed. Available at http://www.fitnesscubed.com/cubii.html

[3] Isbister, K. Emotion and motion: games as inspiration for shaping the future of interface. *Interactions*, September/October (2011), 24-27.

[4] Isbister, K., Rao, R., Schwekendiek, U., Hayward, E. and Lidasan, J. Is more movement better? A controlled comparison of movement-based games. In *Proc. Foundations of Digital Games 2011*, 331-333.

[5] Marshall, J. and Tennent, P. Mobile interaction does not exist. In *Proc. CHI 2013*, ACM Press (2013), 2069-2078.

[6] Maurer, B., Bergner, F., Kober, P. and Baumgartner, R. Improving rehabilitation process after total knee replacement surgery through visual feedback and enhanced communication in a serious game. In *Proc. SIGDOC 2012*, 355-356.

[7] Merleau-Ponty, M. *Phenomenology of Perception*. Routledge, 1962.

[8] Mueller, F., Gibbs, M.R., Vetere, F., Agamanolis, S. and Edge, D. Designing mediated combat play. In *Proc. TEI 2014*, 149-156.

[9] O'Hara, K., Harper, R., Mentis, H., Sellen, A. and Taylor, A. On the naturalness of touchless: putting the "interaction" back into NUI. *ACM Transactions on Computer-Human Interaction 20*, 1 (2013).

[10] Patel, A.V., Bernstein, L., Deka, A., Spencer Feigelson, H., Campbell, P.T., Gapstur, S.M., Colditz, G.A. and Thun, M.J. Leisure time spent sitting in relation to total mortality in a prospective cohort of US adults. *American Journal of Epidemiology 172*, 4 (2010), 419-429.

[11] SBRN (Sedentary Behaviour Research Network). Standardized use of the terms "sedentary" and "sedentary behaviours". *Appl Physiol Nutr Metab 37*, 3 (2012), 540–542.

[12] Slepian, M.L. and Ambady, N. Fluid movement and creativity. *Journal of Experimental Psychology 141*, 4 (2012), 625-629.

[13] TreakDesk. Available at http://www.trekdesk.com/

[14] Wilmot, E.G., Edwardson, C.L., Achana, F.A., Davies, M.J., Gorely, T., Gray, L.J., Khunti, K., Yates, T. and Biddle, S.J. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. Diabetologia 55, 11 (2012), 2895-2905.

Mobile Interaction Trajectories: Designing for Everyday Movement Patterns

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Abstract
Mobile interaction trajectories is a new middle range theory[1] *for* mobile interaction design. The theory draws from novel understandings of mobility. In particular, it focuses on mobile device users' repetitive mobility patterns in everyday life. Research has shown *instances of mobile interaction trajectories* to fruitfully inform mobile interaction design work.

Author Keywords
Mobile interaction design, mobile HCI, mobility, mobile interaction trajectories, theory, design, Probes.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

New thinking in mobile interaction design
The notion of what mobility is, or what it means to be mobile has dramatically changed over the course of the last decades. There has been a limited response to these new theoretical possibilities in HCI (Human Computer Interaction) and interaction design. Recent

[1] In short, a middle range theory *for* design is a theoretical perspective to structure insights about users and context for *particular* design problems.

critique revealed a rather traditional understanding of mobility within these communities. Mobile interaction design retains a rather strong focus on portable devices and on locations [3, 4]. Some research has raised the issue of using novel mobility theories for design purposes [1, 2, 5]. However, these theories remain underexploited by design research approaches, like *probing*.

Mobile Interaction trajectories:

This workshop paper briefly presents *mobile interaction trajectories*, a new middle range theory *for* interaction design that is inspired by novel mobility theories, e.g. [6]. The theory has a strong focus on physical mobility patterns in everyday life.

Mobile interaction trajectories focuses on mediated social interaction in everyday life and considers everyday corporeal movement as a basic structure.

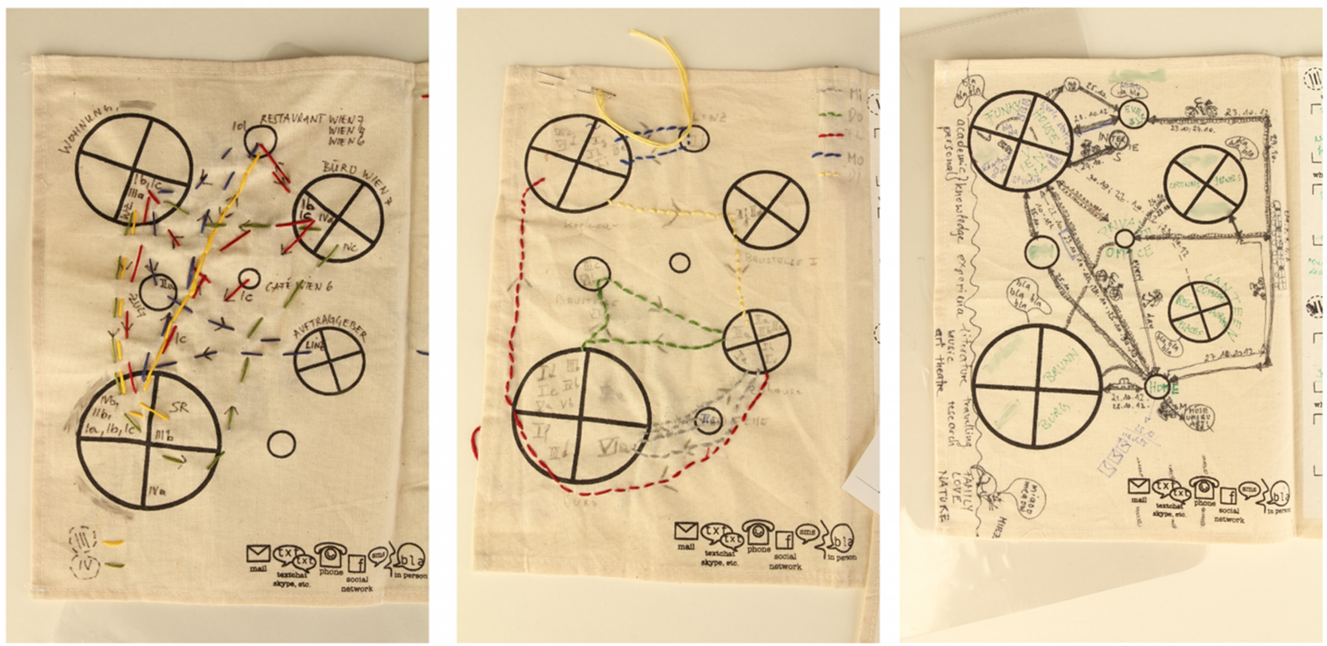

Figure 1: Probes to collect instances of mobile interaction trajectories using space-time diaries: *Circles represent everyday places (home, work, supermarket, etc.). Lines represent everyday routes from and to places, so called trajectories. Completed space-time diaries are presented to designers with additional insights, e.g. summaries and quotes form debriefing interviews.*

The theory aims to overcome a *single location perspective* by focusing on people's everyday trajectories. Embracing *trajectories* rather than *locations in isolation,* such as *work*, *home* or the *urban area,* challenges mobile interaction design's primary focus on such geographic entities. Trajectories are understood as people's everyday journeys that traverse several places of everyday life, such as routes from *home* to *work* and back. The middle range theory presumes that such patterns of physical mobility reoccur. In doing so, the middle range theory looks at a set of interlinked places of everyday life, rather than focusing on one location.

Furthermore, *mobile interaction trajectories* emphasise hyper-connectivity, which refers to being connected to various people continuously. It considers mediated (mobile) communication with other people as rooted in everyday physical mobility and in the context of the 'things' people do. Trajectories determine when, where and how people manage their virtual connections to distant others, and also how they experience these virtual tethers. The middle range theory assumes that being on their individual trajectories, people have developed particular practices to maintain and manage their communication, which lead to new *mobile communication routines*[2], *chronologies of mediated communication* and changing *states of connectedness*.

The following study briefly describes the outcome of two design experiments that researched mobile interaction trajectories' value for generative design processes. Using Probes, the middle range theory of *mobile interaction trajectories* was used to collect and communicate insights about users and contexts to designers.

[2] Mobile communication routines are understood as reoccurring structures of communication, such as regular phone calls to a specific person at a similar time and from similar place. For example, a person's daily phone call during the homeward trip from work, informing his or her partner that s/he is coming home.

Two Design experiments: Study and Results

We used particularly designed Probes to collect and communicate insights, called the Hankie Probes. 15 respondents were asked to express their physical mobility by stitching their everyday trajectories onto a fabric-based space-time diary (see Figure 1). Circles represent research participant's everyday places, lines connecting these places represents everyday trajectories, e.g. *home->work->home*. We asked participants to take notes about their mobile phone use during their everyday trajectories, e.g. when and where they used their phone to stay in touch with other people, which media and services they used, in which contexts they used to communicate and how they experienced their mediated communication.

For the first experiment, we asked 10 couples to record their mobility patterns and to take notes about when and how they stay in touch with their partner via communication media. For the second experiment, we asked 5 office workers to record their mobility patterns and to take notes about their device use to stay in touch with co-workers and clients. We debriefed participants in a 40 minutes interview.

The completed Probes are understood as *instances of mobile interaction trajectories*. The studies created 15 artfully completed space-time diaries that express respondents' individual trajectories and ways of moving through and across the city. The space-time diaries revealed some of respondents' practices and experiences of staying in touch with distant others, and some of their mobile communication routines, chronologies of mediated communication and changing states of connectedness.

The completed space-time diaries were used in design workshops with 28 designers, who were asked to innovate digital services for the displayed mobility patterns, communication practices and experiences. For further explanation, the space-time diaries were presented together with summaries and quotes from the debriefing interviews.

Qualitative analysis of the design workshops showed that the space-time diaries motivated and guided designers' exploration of insights. Design teams particularly benefited from space-time diaries that described rhythmic and recurring patterns of physical movement across several places and contexts of everyday life. These instances triggered design visions that aimed to disrupt and enhance these everyday trajectories with new communication media and services. The trajectory-perspective also revealed interesting places (or combination of places) to focus the design process on, which offered a number of *scopes* for design teams to explore. The described trajectories helped the designers to imagine a design concept to play out over the course of a day and across several places. This guided and supported the design teams' iteration, explanation and evaluation of design concepts.

Conclusion:

The analysis shows that mobile interaction trajectories' emphasis on rooting mediated communication in everyday physical mobility has value for generative mobile interaction design processes. Single location and device centred perspectives in isolation cannot offer these qualities, because they focus on one place/location from the outset. The middle range theory offers a new and so far unexplored theoretical perspective to understand and structure insights about users and context for mobile interaction design.

References

[1] Dourish P. & Bell G. (2011), Divining a digital future, Mess and Mythology in Ubiquitous Computing, MIT Press

[2] Fallman, D. (2003) *In Romance with the Materials of Mobile Interaction: A Phenomenological Approach to the Design of Mobile Information Technology*, Doctoral Thesis, ISSN 1401-4572, RR.03-04, ISBN 91-7305-578-6, Umea University, Sweden: Larsson & Co:s Tryckeri

[3] Fallman, D., (2005), Mobility as involvement: on the role of involvement in the design of mobile support systems for industrial application, AI & Society 25, pp. 43--52

[4] Jumisko-Pyykkö, S. & Vainio, T., (2010), *Framing the Context of Use for Mobile HCI. Review paper about mobile contexts of use between 2000-2007*, International Journal of Mobile Human Computer Interaction (IJMHCI), Volume 2, Issue 4, pp. 1--28

[5] Kakihara, M. & Sorensen, C. (2002), *Mobility: an extended perspective*, in Proceedings of the 35th Hawaii International Conference on System Sciences, IEEE, Los Alamitos CA, pp. 1756—1766

[6] Urry, John; Mobilities, Polity Press, 2007

Designing Smart Cities: Rhythm Is The Answer

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Abstract

This paper discusses rhythm as one design principle in a smart city planning. Architects and urban planners have studied how to design urban environments and support moving from place to another from as early as 40 eaa. The idea presented in this workshop paper is based the re-interpretations of my prior doctoral research on how to apply urban design principles into the design of mobile navigation tools for pedestrians. I argue that one of the applicable and interesting design principles is rhythm. In this paper, I suggest that in a

smart city planning, technology can enhance the designing by providing more rhythm into real city environments.

Author Keywords
Smart city planning; navigation; planning process

ACM Classification Keywords
J.5 ARTS AND HUMANITIES

Introduction
Navigation, and therefore moving from one place to another, has been the focus of a huge amount of scientific research over the past few decades, not only in the field of human-computer interaction (HCI), but also in the fields of psychology, see [11, 2], human geography [4] and urban planning [14, 6, 1]. In fact, it can be argued from the evidence that psychologists, geographers and architects have studied human navigation for longer than computer scientists have. In 1948 Tolman [10] argued that navigating is to some extent a personal ability or skill, and a human being creates a personal cognitive map in order to be able to navigate better in the world. Lynch [6] later explored the extent to which these cognitive maps could support navigation in Chicago during the 1960s, and he defined six elements that support navigation in an environment. Furthermore, as early as in 40 eaa, Vitruvius discusses designing symmetry, eurythmy, order and economy as design principles for architects, see [14 5, 8]. Thus, moving in a environment and the design of how to support moving have been the subject of scientific research for a long time, longer than research into human-computer interaction.

Episodes of motion
For most HCI researchers Lynch's [6] imageability is familiar with design elements such as landmarks, paths, nodes, edges and districts. In my doctoral study [12], I investigated the design principle of episodes of motion [7, 3] which are continuum of Lynch's [6] design elements, but they present the design idea of rhythm. These design principles of episodes of motion focus on the design of a series of places and the design of the user's moving experience in the physical environment; that is, for example, a human being with a mobile device finding their way in a smart city environment.

As with Lynch's [6] imageability, the design practice of episodes of motion consists of design elements. Regarding the moving experience in urban planning, the *starting* and the *ending* points are important elements, which ought to be designed carefully. Furthermore, the implementation of how the *continuum* between the separate places should be represented is also crucial, as well as designing how to *lead the user from one episode to another*. In their studies, Stenros and Aura [7] and Aura [3] produced some additional principles for designing episodes of motion for urban planning. Firstly, it is important to design routes that can be recognised as part of the whole system, for example, as part of the city. Secondly, when designing a single episode, some kind of clue that indicates how the place is going to continue after the episode is relevant. Thirdly, variation within a single episode will help to make that episode interesting. The fourth of Stenros's and Aura's [7] design principles is related to the rhythm of a place. The aim of designing a rhythm in an episode is to make an episode interesting for a human. Designing the rhythm is related to visualising the environment; for example, designing according to the gestalt laws. The final principle in episodes of motion is the idea of designing open views and spaces in a route that can help the user to visualise overall spaces better [4].

Rhythm and smart cities

I would like to discuss during the workshop particularly about the rhythm as a design principle in smart city environments as my current research topic is a smart city planning process. Smart technology and the existing rhythm in urban physical environment, for example, with narrow streets and squares, should pull together while walking throughout the city. Another example is fluent and smart traffic lights, but not only for car drivers also for bicyclists, too.

However, the idea of connecting human-technology interaction and rhythm is not totally a novel one. For example, Tamminen et al. [9] stated that there are temporal tensions within the mobile context, such as acceleration, deceleration, hurrying, normal and waiting. Furthermore, regarding user interface design issues, modality selection and interruption management are two of the main issues in mobile navigation [9]. Rhythm can also support mobile pedestrians with multimodal navigation tools in wayfinding in unfamiliar urban environments [13].

So designing rhythm can be one approach to smart city planning. Therefore, I suggest for further discussions following issues:

- How to design appropriate tempo and duration in smart cities?
- How to study what is the appropriate tempo and duration in smart cities?
- Does the technology supported rhythm in a smart city vary according to the time of the day?
- How should the citizens be involved when designing the rhythm of the smart city?

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References

1. Alexander, C., 2003. *The Nature of Order: an essay on the art of building and the nature of the universe*, Center for Environmental Structure, 2003.
2. Allen, G. L. 1999. Spatial abilities, cognitive maps, and wayfinding: Bases for individual differences in spatial cognition and behaviuor. In R. Golledge (Ed.), Wayfinding behavior: Cognitive maps and other spatial processes Baltimore: Johns Hopkins University Press, 46-80.
3. Aura, S. 1989. Episodi liikkumisen analyysiyksikkönä rakennetusta ympäristöstä liikuttaessa saatavan esteettisen kokemuksen ympäristöpsykologinen tarkastelu Tampere. TTKK, 1989. Tampereen teknillinen korkeakoulu. Julkaisuja 58. (Academic Dissertation 1989, Tampere University of

Technology, Publication 58)

4. Golledge, R., D. and Stimson, R.J., 1997. Spatial behavior. A geographic perspective. New York. Guildford Press
5. Honour, H.& Fleming, J. 1991. A World History of Art. John Calmann & King Ltd., London.
6. Lynch, K. 1960. Image of the City. Cambridge: The technology press & Harvard University press.
7. Stenros, H., and Aura, S. 1987. Time, Motion and Architecture. Weilin +Göös, Espoo.
8. Summerson, J.. 1980. The Classical Language of Architecture. Thames and Hudson Ltd.
9. Tamminen, S., Oulasvirta, A., Toiskallio, K., and Kankainen, A. 2004. Understanding mobile contexts. Personal Ubiquitous Comput. 8, 2 (May. 2004), 135-143
10. Tolman, E. 1948. Cognitive maps in rats and men. Psychological Review 55 (1948), 189–208.
11. Tversky, B. 2003. Navigating by mind and by body. In Freksa et al. (eds.) Spatial Cognition III, Springer-Verlag, 2003
12. Vainio, T. 2010. Applying Urban planning and Design Principles into the Design of Mobile Multimodal Navigation Aids. Academic Dissertation 2010, Tampere University of Technology, Publication 924)
13. Vainio T., 2011. Designing Multimodal Tracks for Mobile Navigators to follow in Unfamiliar Urban Environments. In Digital Creativity, Taylor & Francis. Vol. 22, No.1, 1-14
14. Vitruvius: The Ten Books on Architecture. Vitruvius. Morris Hicky Morgan. Cambridge: Harvard University Press. London: Humphrey Milford. Oxford University Press. 1914. Available at < http://www.perseus.tufts.edu/cgi-bin/ptext?lookup=Vitr.+1.2.1 >.

Preventing Cognitive And Physical Decline Through Bodily Interaction With Music

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Abstract
This paper briefly describes initial research into movement-based interaction design, and argues that there is significant potential for addressing and improving the health and well-being of senior citizens through bodily interaction with music. Music is increasingly recognized as a viable tool in the treatment and prevention of age-related cognitive and physical decline. A number of simple prototypes were designed to explore couplings between bodily movements and musical rhythm. They are to be used as points of departure for a participatory research-through-design process where senior citizens are involved in the exploration and design of movement-based interactive systems. Preliminary findings suggest that even simple and basic couplings between bodily movements and music can provide interesting and enjoyable interactions, as well as physical and cognitive stimulation.

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Author Keywords
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ACM Classification Keywords
H.5.2. [Information interfaces and presentation]: User interfaces---Auditory (non-speech) feedback, Input devices and strategies, Interaction styles.

General Terms
Design, Experimentation, Human Factors

Introduction
Senior citizens are at risk of a range of different age-related health issues, such as dementia, stroke, chronic heart disease, fall-related injuries, among others. On a general level, physical and cognitive decline increases with age and inactivity. Many seniors find it difficult to maintain a sufficient activity level to prevent this decline and thus enter a downward spiral where lack of

physical activity leads to further decline. In addition, common fall-related injuries often immobilize seniors for sustained periods of time, with detrimental effects for their physical and mental health.

It is well known that physical activity improves health. It has also proven to be beneficial for treating a range of behavioral and psychiatric symptoms related to dementia [7], [3]. Furthermore, although more research is needed [11], studies have indicated that music, dance, and participation in cultural activities also have positive effects on patients suffering from dementia [10], [12], [13].

This paper argues that there are multiple opportunities for addressing age-related health issues through the combination of music and movement-based interaction. The advent of affordable, yet advanced, sensor systems like the Microsoft Kinect, Leap Motion, Nintendo Wii, and the Arduino prototyping platform has opened up entirely new possibilities for direct bodily interaction with music and audio.

Related work

Within HCI, there is a growing interest in movement-based interaction, kinaesthesis, and embodiment in interactive systems. Dourish coined the term *embodied interaction* as "the creation, manipulation, and sharing of meaning through engaged interaction with artifacts" [2]. A number of frameworks, methods and approaches have been developed to help researchers and designers understand, explore, design and test movement-based interaction with technology[8]. In both [4] and [6] it is argued that the designer of movement-based interactions needs to experience movement personally in order to understand the subject matter and the potentials of the design material.

Music is increasingly being recognized as a viable way of treating and preventing age-related health challenges [11], and it is often used in combination with physical exercise [9], [10]. Music is used to reduce stress and agitation, access lost memories, process emotional issues, communicate, and improve motor and cognitive functions [10]. Within music therapy there is a growing interest in using electronic music technologies in therapeutic settings, but little guidelines or systematized knowledge about how to do this [5].

Music and movement are closely related through both performance and listening, and provides ample opportunities for the exploration of movement-based / whole-body interactions. In [1], music and tangible interactive artifacts were used as a way to improve health and well-being for families with children with severe disabilities. To the author's knowledge, there is no existing research that investigates the potential for preventing or reducing age-related cognitive and physical decline through whole-body interaction with music. This work aims to contribute to research in this direction.

Intentions

The intention with the current research is to involve senior citizens in a participatory research-through-design process, where possibilities for health-promotion and well-being through embodied interaction with music are explored. This entails designing and evaluating prototypes that provide physical, cognitive, and social stimulation through meaningful and pleasurable interactions with music. Thus, the focus is

All four gestures illustrated above have identical effects on the system.

not on addressing specific disabilities or symptoms, but rather on providing fun, meaningful and stimulating ways for people to be more active.

Initial exploratory prototypes

Using the Microsoft Kinect motion sensor to track users' movements, some initial prototypes have been made that explore how bodily movement can be used to control the tempo of a piece of music. There were two main purposes with these prototypes: First, it was to explore some simple design ideas and get an experiential understanding of what the ideas would "feel" like in action. Second, the prototypes will be used as illustrations, or points of departure, for inviting participants to take part in the further design process.

The Human Metronome

The prototypes are variations over the same basic idea that rhythm, tempo and bodily movement are closely related. When we listen to music the rhythm often manifests itself, consciously or unconsciously, in repetitive movements of some part of our body.

The basic conceptual idea behind the prototypes is that of a conductor conducting an orchestra. By moving his hand horizontally back and forth, he can control the tempo of the performance. Admittedly, an orchestra conductor uses a wide range of gestures to communicate with the orchestra, and the meanings of these go way beyond simple tempo control. However, for the sake of simplicity in the initial exploratory stages, the focus has been on tempo control through repetitive body movements.

Both musical tempo and repetitive body movements are variations over a period of time. The prototypes take advantage of this fact by synchronizing the tempo of the music to the tempo of the user's movements. In practical terms, this implies that if the user is moving at a lower or higher frequency than the tempo of the music, the tempo will change until it matches that of the user.

Discussion

Testing of the prototype has been limited but promising at this point. Accordingly, the following findings may be considered preliminary and tentative, and are intended as a basis for further research.

One important realization has been that whole-body interaction with music does not have to involve designing for the *whole* body. Even though the user of the prototype is simply required to move one hand back and forth, the meaning this movement takes on is transformed when the music starts adapting to the tempo of the movement. The user and the system enter into a musical dialogue, a perceptual loop where the changing tempo of the song affects the speed of the user's movements, which in turn affect the tempo of the music. It takes mental determination, rhythmical awareness and bodily control in order to stabilize the tempo. But once the user is able to do so, he also resonates with the music on an embodied level that inevitably draws the rest of the body into the movement. Thus, the whole body is interacting with the music through the tracking of a single body-part in one-dimensional space (horizontal / x-axis).

Furthermore, employing such a basic input mapping leaves room for personal expression. The trajectory of the hand can interchangeably describe: a horizontal line; the symbol of infinity (∞); a circle; or a u-shape (see sidebar), as long as the frequencies of the movements are the same. The same input mapping can also invite and avail for anything from slow and delicate movements to energetic and intense, depending on the quality of the music and the user's interpretation of it.

Conclusions

It has been demonstrated that there is potential for providing physical and cognitive stimulation through embodied interaction with music. Simple couplings between music and bodily movements can entice the user into the rhythm of the music and provide expressive and meaningful interactions. Further research will explore possibilities and relationships between embodied interaction, music, health, and well-being.

References

[1] Andersson, A-P., Cappelen, B., Olofsson, F. Designing Sound for Recreation and Well-Being, *Proc. Int. Conf. New Interfaces Music. Expr.*, (2014).

[2] Dourish, P. *Where the Action Is: The Foundations of Embodied Interaction*. Cambridge, Massachusetts: The MIT Press, (2004).

[3] Helbostad, J.L. Fysisk trening av sykehjemsbeboere – har det noen hensikt?, *Tidsskr. - Tidsskr. Den Nor. Legeforening*, (2005).

[4] Hummels, C., Overbeeke, K. C. J., Klooster, S. Move to get moved: a search for methods, tools and knowledge to design for expressive and rich movement-based interaction, *Pers. Ubiquitous Comput.*, vol. 11, no. 8, pp. 677–690, 12 (2007).

[5] Knight, A., Lagasse, A. B. Re-Connecting to Music Technology: Looking Back and Looking Forward, *Music Ther. Perspect.*, vol. 30, no. 2, pp. 188–195, 1 (2012).

[6] Larssen, A. T., Robertson, T., Edwards, J. Experiential bodily knowing as a design (sens)-ability in interaction design, *Proceedings of the 3rd European Conference on Design and Semantics of Form and Movement*, (2007), pp. 117–126.

[7] Lautenschlager, N.T., et al. Effect of physical activity on cognitive function in older adults at risk for alzheimer disease: A randomized trial, *JAMA*, vol. 300, no. 9, pp. 1027–1037, 9 (2008).

[8] Loke, L., Robertson, T. Moving and Making Strange: An Embodied Approach to Movement-based Interaction Design, *ACM Trans Comput-Hum Interact*, vol. 20, no. 1, pp. 7:1–7:25, 4 (2013).

[9] Myskja, A. *Den siste song*, Bergen Fagbokforlaget, (2006).

[10] Myskja, A. *Musikk som terapi i demensomsorg og psykisk helsearbeid med eldre*. (2009).

[11] Sherratt, K., Thornton, A., Hatton, C. Music interventions for people with dementia: a review of the literature, *Aging Ment. Health*, vol. 8, no. 1, pp. 3–12, (2004).

[12] Skjei Knudtsen, M., Holmen, J., Håpnes, O. Hva vet vi om kulturdeltakelse og helse?, *Tidsskriftet.no - Tidsskrift for Den norske legeforening*, (2005). [Online]. Available: http://tidsskriftet.no/article/1306992. [Accessed: 29-Sept-2014].

[13] Svansdottir, H. B., Snaedal, J. Music therapy in moderate and severe dementia of Alzheimer’s type: a case–control study, *Int. Psychogeriatr.*, vol. 18, no. 04, pp. 613–621, (2006).

When Swipe Is Not Just a Swipe: On Explicating the Qualities of Movement for Gesture Design

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Abstract
As the use of gestures and other forms of body-based control in human-computer interaction is increasing, it is relevant to take a look at the ways that body movements are conceptualised in interaction design. In this paper we argue that, in addition to outlining gestures as general types of action (e.g., swipe), an equal emphasis should be put in particularising and describing the way in which the action is performed. Some existing approaches and practices for explicating this 'felt essence' in the dynamic qualities of movement are outlined and discussed.

Author Keywords
gestures, interaction design, movement, notation

ACM Classification Keywords
H.5.2 [User Interfaces]: Theory and methods.

Introduction
One of the growing challenges of interaction design relates to appropriate usage of body-based, gestural controls in user interfaces. A part of this challenge is in creating controls in which body movements feel natural and avoid being too mechanistic. The recognition that cognition is embodied action [1] brings forth the fundamental idea that human actions are embedded with a range of situated, tacit meanings which cannot be overlooked in

gesture design. In fact, it could be said that every move we make manifests intentionality that we live through our body [6]. And even the smallest nuances and dynamic changes in those movements – i.e., the way the movement is actualised – manifest the type of felt meanings often referred as vitality affects [11]. The importance of these implicit meanings is emphasised by the recognition that they relate to the first means we form knowledge of the body and the world we are living in [10, 11, 3].

In terms of Laban's movement analysis (LMA, see [4]), the domain of felt meanings, the 'inner attitude' and intentionality relate to the category of movement called *Effort*. All body movements have the effort-element, which manifests in body's shaped configuration in space and in the procedural qualities of movement. Even in case of a specific type of action, such as a swipe of the hand, the effort can be different (thrusting, sliding, stroking, slashing, and so on). As these qualities of body movement are coupled with intentionality directed to the environment, it is important to acknowledge that the details of motion are equally relevant to both the felt and the functional essence of the movement.

We argue that in designing gestures, mere outlining of them as general types of action is insufficient. An equal emphasis should be put in particularising and describing the exact way (and intention) in which the action is performed. Even definitions of shape and direction of the body movement needs to be coupled with more detailed descriptions of (contextually motivated/justified) movement qualities and the precise effort of action. Next, we review and discuss some practical approaches and methods for explicating such details in design documentations.

Explication approaches

Verbal descriptions

One of the most straightforward ways of explicating and communicating the particularities of movement is trying to describing them verbally. It almost seems self-evident that careful choice of words in conceptualising and sketching gestures can indeed convey lots of details of the intended movement, its effort and the dynamic experience attributed to it. For example, words such as thrusting or sliding may be used as an qualitative attribute to the swiping gesture in question. One could say that the problem of verbalisation is that the movement details remain fuzzy due to the interpretation required. However, the interpretation of action-related words are not necessarily far separated from the experience of concrete actions [3], and it may even involve enactive or ideomotoric apprehension of the activity referred in the word [2]. All in all, conceptual design should consider systematic, deliberately rich use of verbal expressions in describing the explicit dynamic attributes of an intended gesture.

Analysis of effort

Outlining a specific effort involved in the intended gesture should give support to the conceiving of its particularities and qualities as a bodily action. In Laban's terms [4], effort describes simultaneously the intention of the movement within its affection and intensity. For instance, in swiping gestures of either *thrusting* or *sliding* type, the control of the movement, the strength of the movement and the timing of the movement are very different. Effort has four subcategories (Effort Factors), each of which has two opposite polarities (Effort Elements). Effort factors and the respective polarities are shown below:

- **Space**: Direct vs. Indirect (Flexible)
- **Weight**: Strong vs. Light

- **Time**: Sudden vs. Sustained
- **Flow**: Bound vs. Free

For instance, thrusting something away is a determined act, in which the movement of arm is usually *direct, sudden* and *strong*, while in sliding action the moving arm is *sustained, light, direct* and *bound*. Different combinations of effort elements thus effectively characterise different movement qualities and the related types of action.

Notation and illustrations of movement
In addition to verbal descriptions and categorical analysis, there is usually a need to visually illustrate the intended movement. Graphical descriptions of movement can be effective, as they may iconically as well as indexically refer to the actual structure and/or the process of movement. Different types of *ad hoc* illustrations of gestures are common in design documentations (see Figure 1), but while they are intuitive they often lack in terms of describing movement qualities (i.e., how the movement is performed). Moreover, they are usually not well suited for illustrating flows and rhythms of movement that goes beyond a single move of the body. For that, designers can use movement notation systems, such as Labanotation which is a close equivalent to musical notation in many respects. As being a comprehensive body-centered notation system Labanotation clearly has much to offer in body-based interaction design (see, e.g., [5]), but it also its drawbacks. The highly symbolic and formal nature of notation means that the felt essence of movement may not be that intuitively perceivable.

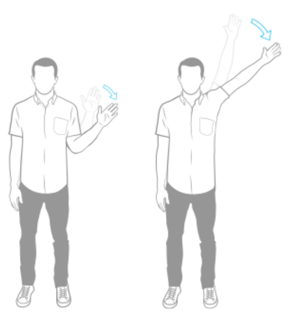

Figure 1: Typical illustrations of hand gestures (form Kinect Human Interface Guidelines [7]).

Bodily sketching
Design practices for body-based interaction almost certainly involve at least some kind of formal or informal bodily experimenting (i.e., bodystorming, see [8]) with regards to gestures, their form, function and situational appropriateness. This kind of enactive sketching of body movements allows tacit utilisation of 'kinaesthetic thinking' [12] that goes beyond the reflective (cerebral) design conceptualisations. During bodystorming sessions, it makes sense to produce manually performed sketches of body movements, that appear experimentally appropriate both in terms of function and feeling. Different means can be utilised for recording the performance, and as a further step, for extracting dynamic envelopes that explicate certain aspects of movement qualities.

When sketching a gesture it is essential to acknowledge the situational context as well as the related intentionality of the act. In that way, sketches of movement should physically manifest contextually appropriate motor intentionality embedded in our spontaneous body actions (see, e.g., [13]). Moreover, sketching may also involve use scenarios that put the single swipe of the arm into the larger continuum of bodily choreographies [9].

Concluding statements
In this paper we proposed justifications for putting more emphasis to describing the particularities of movement and its felt qualities in designing gestures. On the basis of the brief review of some practical methods for explicating those qualities in design, the key for utilising these approaches seems to lie in finding out a balanced combination of them all to be used in different phases of design. Still, it also seems that a strong need remains for developing a specific movement notation system, suitable for interaction design.

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References
[1] Dourish, P. *Where the Action Is: The Foundations of Embodied Interaction*. The MIT Press, Cambridge, MA, 2001.

[2] Gallese, V., and Lakoff, G. The brain's concepts: The role of the sensory-motor system in conceptual knowledge. *Cognitive neuropsychology 22*, 3 (2005), 455–479.

[3] Johnson, M. *The meaning of the body: Aesthetics of human understanding*. University of Chicago Press, Chicago, IL, 2007.

[4] Laban, R. *Mastery of movement. revised by Lisa Ullmann*. London: MacDonald and Evans, 1980.

[5] Loke, L., Larssen, A. T., and Robertson, T. Labanotation for design of movement-based interaction. In *Proceedings of the second Australasian conference on Interactive entertainment*, Creativity & Cognition Studios Press (2005), 113–120.

[6] Merleau-Ponty, M. *Phenomenology of Perception*. Trans. C. Smith. London: Routledge (Original work published 1945), 1962.

[7] Microsoft. *Kinect for Windows: Human Interface Guidelines v1.8. Available from http://go.microsoft.com/fwlink/?LinkID=247735*. Microsoft, 2013.

[8] Oulasvirta, A., Kurvinen, E., and Kankainen, T. Understanding contexts by being there: case studies in bodystorming. *Personal and Ubiquitous Computing 7*, 2 (2003), 125–134.

[9] Parviainen, J., Tuuri, K., Pirhonen, A., Turunen, M., and Keskinen, T. Gestures within human-technology choreographies for interaction design. In *Proceedings of the 10th International Gesture Workshop and the 3rd Gesture and Speech in Interaction Conference*, Tilburg University (2013).

[10] Sheets-Johnstone, M. *The primacy of movement*. Amsterdam: John Benjamins Publishing Company, 1999.

[11] Stern, D. *Forms of vitality: exploring dynamic experience in psychology, the arts, psychotherapy, and development*. Oxford Univ Pr, 2010.

[12] Svanæs, D. Kinaesthetic thinking: The tacit dimension of interaction design. *Computers in Human Behavior 13*, 4 (1997), 443–463.

[13] Tuuri, K. *Hearing Gestures: Vocalisations as embodied projections of intentionality in designing non-speech sounds for communicative functions*. PhD thesis, University of Jyväskylä, 2011.

Kinesthesia in experience prototyping: pedestrian services in a virtual intelligent environment

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Abstract
Urban design plans have already been presented from various perspectives and in different media, yet prototyping of the bodily sensation of movement (known as kinesthesia) has previously been technically out of the reach. Kinesthetic empathy [2] has the potential to help professional designers to reach for the user's experience of movement and interactions within future service environments. With new interfaces and sensory input devices, empathy building can be completed with experience prototyping [1] kinesthetic qualities of the future user's experience. In our study, kinesthesia is seen as a promising concept which widens the scope of empathy [6] within the fields of urban and interaction design.

Author Keywords
urban design; empathic design; interaction design; kinesthetic research; experience prototyping

ACM Classification Keywords
HCI

Introduction

When designing virtual experience prototype where interactions unfold in time and space, relative to the experiencer's body in movement, the naturalness of the subject's experience calls for designing a constant and coherent flow of user-centered sensuous interactions. The focus of this paper is to describe our design context, that is, how to understand pedestrian services in an intelligent environment from the perspective of the body in movement. In the end of the paper we will describe our research approach. We intend to prototype conceptual design of future intelligent environment situated at the Aalto University campus in Otaniemi, Finland with emphasis on kinesthetic credence of the prototype.

Designing for bodies in movement

The theme of mobility, including traffic and transportation systems, has been at the heart of societal development throughout the history of humankind yet aspects related to safety, comfort, efficiency and environmental sustainability are still far from satisfactory [11]. One of the areas that has received little attention in the wider sphere of future mobility studies, is pedestrian services. Martinez et. al. [7] foresee that the convergence of telecommunication, computing, wireless and transportation technologies will turn roads into communication and transportation platforms which will revolutionize when and how we use services and entertainment, how we communicate, and how we commute and navigate. Furthermore pedestrian experience is in the midst of technological upheaval and new solutions affecting pedestrians' possibilities to move and engage with services in urban environments will be introduced. Although little is known about how tomorrow's socio-technical systems will affect total pedestrian experience, it is certain that these services will be experienced subjectively through the body in movement. Therefore, it is crucial that these technologies are developed on the basis of a strong understanding of human sensorimotor schemas, see also [8].

Movement generates complex interrelations that are an essential part of the life of a city. Hence urban design should have the choice of starting from movement [4]. Environments are frameworks for movement activities and as such they can influence our lives tremendously. Our environments have become more dynamic. They are spaces within which many kinds of activities take place, and these should be designed with the moving person in mind. Movement can be designed in such a way that it flows easily in interesting patterns and is varied in its textures and backgrounds. When the environment supports movement that is rhythmically united, it has the potential to influence people's movement patterns through its spaces, resulting in a fine sense of dance in the body of the person experiencing it [3].

Interaction design should aim at extending this 'sense of dance' to all sorts of the physical, technological and social interactions that we face when moving and interacting with services. Solely smart objects, such as personal communication devices, have become so common that the pedestrian experience in urban space can no longer be understood without consideration of individual gadgets as a part of total experience. Thrift [10] provides some valuable ideas in shaping the relationship between the body and technology by stating that human beings should not be understood as something separated from the 'thing world'. Instead, it could be argued that the body is what it is because of 'its unparalleled ability to co-evolve with things.' Usage of things, as if bringing augmentations to different parts of the biological body, shows the human body as a constantly evolving distribution of different hybrids with different reaches. These new reaches, enhanced by technological developments, provide opportunities for new mediated, mixed and augmented experiences. In movement environments, objects and other people become part of our body's interaction choreographies.

Pleasant pedestrian movement, well-designed environments and smart devices can all be associated with the idea of the intelligent environment that becomes reality when smart objects in the environment start to interact seamlessly with our personal smart devices and, on the basis of machine-to-machine communication, feed us with accurate contextual information. According to Kaasinen et. al. [5] intelligent environments are characterized by information and communication technology embedded so seamlessly into our physical environments and in various everyday objects that ICT-enabled features will become a natural part of our living and working environments. While people use intelligent environments they simultaneously inhabit them. In this respect, an intelligent environment is more than just a relationship between a user and an intelligent system. The usual systems and technology-orientated way that intelligent transportation systems are planned and designed currently is not sufficient to cope with the kinesthetic qualities of future pedestrian experience. Due to its fundamental nature, design approach that adopts the idea of empathy and kinesthetic experience prototyping should be adopted into the strategic design process where the characteristics of development directions for future pedestrian service environments are being outlined.

In our research, we will first recognize, define and analyze some of the interaction choreographies that a group of dancers are engaged with when moving in the Aalto University campus in Otaniemi. Kinesthesia is regarded as an integrated multisensory experience of movement, hence we will use analytic tools of sensuous geography [9] to 'decode' the dancers' interactions with objects, architecture and other people into haptic, auditive and visual categories. The analysis is conducted respecting the context of dance as a specific embodied spatio-temporal practice which is loaded with particular social and personal meanings. Second, this acquired understanding of the dynamics of (sensuous) interactions and the dancers' (kinesthetic) experience will be used to inform and inspire the creation of an interactive 3D model.

We wish to be able to evaluate the potential of kinesthetic empathy in urban design with a working experience prototype. The prototype is conceptual and focuses on human-robot interaction. Building on 3D visual art, interactions powered by a game engine, and Head Mounted Display (HMD) interface we shall endeavour to translate kinesthetic and sensuous mechanisms from a 'real world' case study into the virtual domain. Besides the sensory input devices, such as HMDs, the subject's own body is considered as a vital source of sensorimotor input. Although HMD's are already quite widely deployed in urban design projects, the kinesthetic applications are in their infancy. There are lessons to be learned from the embodied gaming industry.

The virtual environments' strength is in presenting solutions without parallel in the real world which allows expression of radical technological visions. The game engine brings with it advanced graphics and dynamic interactions that together provide a whole range of new possibilities for experience prototyping future scenarios. We have located the value of our approach at this level, in helping to steer design and development activities in an institutional level, for instance, processing of crafting technological roadmaps and preparing international research programs. Most importantly, first-person experience prototype emphasizes empathy – walking in the shoes of the future user concretizes very tangibly the influence and consequences of strategic decisions on the level of a subject's lived experience.

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References

[1] Buchenau, M. and Fulton-Suri, J. Experience prototyping. DIS '00, (2000), 424-433.

[2] Foster, S. Choreographing empathy: Kinesthesia in performance. Routledge, 2011.

[3] Halprin, L. The choreography of gardens. Impulse: Annal of Contemporary Dance (1949), 32-33.

[4] Halprin, L. Motation. Progressive Architecture (1965), 126–128.

[5] Kaasinen, E., Kymäläinen, T., Niemelä, M., Olsson, T., Kanerva,. and Ikonen, V. A user-centric view of intelligent environments: User expectations, user experience and user role in building intelligent environments. Computers (2013), 1-33.

[6] Koskinen, I., Mattelmäki, T. and Battarbee, K. Empathic design: User experience in product design. IT Press, 2003.

[7] Martinez, F. J., Toh, C-K., Cano, J-C., Calafate, C. T. and Manzoni, P. Emergency services in future intelligent transportation systems based on vehicular communication networks. IEEE Intelligent Transportation systems Magazine. (2010), 7.

[8] Parviainen, J., Tuuri, K. and Pirhonen, A. Drifting down the technologization of life: Could choreography-based interaction design support us engaging with the world and our embodied living? Challenges (2013), 105–106.

[9] Rodaway, P. Sensuous geographies: body, sense and place. Routledge, London, New York, 1994.

[10] Thrift, N. Non-representational Theory: Space, Politics, Affect. Routledge, 2008, 10.

[11] Qu, F., Wang, F. and Yang, L. Intelligent transportation spaces: vehicles, traffic, communications, and beyond. IEEE International Conference on Wireless Access in Vehicular Environments (2010), 136

From Metrics to Patterns: Towards Automated Analysis of User Behavior with Public Displays

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Abstract
Understanding the use of public display applications is critical to their successful design. Public displays are typically evaluated in field studies and deployments, where the usage analysis is often based on quantitative metrics and observation-based descriptive models. As an alternative approach, we propose the use of automated analysis methods and interactive information visualization to identify temporal and spatial patterns in log data. Using both observational and large scale log data, it is possible to combine *what* the users are doing with *how* they are doing it, and use the insights to inform public display interaction design.

Author Keywords
Embodied interaction; exploratory sequential data analysis; interaction patterns; public displays.

ACM Classification Keywords
H.5.2 [**Information interfaces and presentation**]: User Interfaces --- *Evaluation/methodology*.

Introduction
Interactive display surfaces are gaining prominence in public settings. For example, shopping centers and public transportation hubs can in this way provide

guidance and service information to visitors. The modes of interaction with public displays are still relatively limited, although novel techniques such as mid-air gestures, gaze direction and spoken interaction are increasingly utilized. These extend the interactive area from the display surface to the area surrounding the display, and allow different forms of implicit interaction based on users' location, direction of movement, and level of attention towards the display.

Our current research is focused on designing and studying multimodal and spatial interactions with public displays in real world settings. This workshop paper discusses our ideas for augmenting usage metrics and descriptive models with behavioral patterns extracted from movement and interaction logs.

Studying Public Display Usage

The evaluation of public display applications can have several aims and it can take place at different stages of the research process, from studying specific interaction methods to investigating societal impact. Due to their nature as real world artifacts that are situated in a specific context of use and serving a specific set of users, the study of public display applications is rarely feasible in laboratory environments. Unsurprisingly, descriptive field studies of public display prototypes are a popular evaluation paradigm for public display applications [8]. Common research methods for field studies include observations and logging [1]. Field study protocols typically capture of both qualitative data and quantitative metrics, the latter of which Müller *et al.* [8] categorize into five types: absolute and relative amount of users, number and duration of interactions, and number of simultaneous users. Alt *et al.* [1] distinguish between field studies with limited duration and scope and long-term deployments, during which the system is integrated into the prospective users' daily life and is iteratively improved over time.

One of the major challenges with field studies and deployments is their high cost, in terms of setting up the study, running it, and capturing and analyzing the data. Especially longer deployments would stand to benefit from automated data capture and analysis methods that require minimal manual intervention. For example, manual observation is often impractical over extended time periods (months) and the annotation and coding of the material is labor intensive. While automated logging of interactions and user behavior allows for large data sets to be captured, efficient tools are needed to make the analysis of the data practical. With respect to analytical constructs, easy to compile metrics such as number of users, conversions, or duration of use can fail to capture the complexity of user behavior, especially with respect to the spatiotemporal patterns in movement, interaction, and collaboration. According to Müller et al. [8], more comprehensive descriptions of the interaction process, such as diagrams showing transitions between different states, can be helpful in describing how the system is used, highlighting discrepancies between the designed and actual use, and informing future hypotheses.

In an effort to address these challenges, we are currently developing automated methods for analyzing public display usage patterns based on anonymous log data such as users' movement patterns, body posture, gesturing, and interface interactions. Our aim is to develop methods that can reduce the burden of data analysis, while at the same time providing more detailed characterizations of salient user behaviors.

Example Study: Information Wall

We have collected a data set from an ongoing deployment of *Information Wall*, a gesture-based public display application that provides contextual information (e.g., cafeteria menus and local events) in a higher education setting. The deployment began in April 2013 and the system has been continuously improved while in use. The data set from April 2013 to April 2014 includes traces of over 100 000 users. The data contains locations data from users that passed through the deployment area, and joint coordinates and interface interactions from users who ventured close enough to engage with the system. The Microsoft Kinect for Windows sensor and SDK were utilized to implement the gesture and pointing based interactions and capture joint and location data.

Thus far we have utilized simple heuristic rules, which combine metrics such as duration of use, number of interactions, and user orientation, in order to characterize user behavior along the categories presented in the Audience Funnel framework [6]. Although we have gained some insights into how the Information Wall is used, we believe that more detailed usage patterns can help us discover how different types of users engage with the system. For example, we are interested in investigating how the dynamics of movement and interaction change between individual and social use of the system.

From Metrics to Patterns

The most promising way forward in our analysis we have identified is to look at sequences of interactions and behaviors by adopting an exploratory sequential data analysis approach [2]. The main approaches for extracting and analyzing interaction sequences include sequence detection, comparison, and characterization [3]. In the context of public displays, sequence detection and comparison are related to the operationalization of existing frameworks (e.g., [6, 10]) in order to identify similar patterns in the log data and compare them to existing models.

Sequence characterization, on the other hand, attempts to summarize salient patterns in the data. The advantage here is that the patterns emerge from the data and are not based on predefined models, which may not be applicable for the system under study. For example, Mankowski *et al.* [5] developed a technique that automatically finds representative sequences of behaviors without the need for *a priori* models. Müller *et al.* [8] proposed a semi-automated approach for identifying interaction sequences from anonymous video. Moreover, effective, interactive representations are the key for identifying the identified behaviors. Examples from the domain of game analytics [7, 11] suggest that interactive spatiotemporal visualizations that allow data aggregation, filtering and clustering of similar behaviors could be helpful here. As an example from the public display domain, Williamson and Williamson [12] presented an approach that automatically detects and visualizes pedestrian traffic flows around a public display installation.

In addition to studying post-hoc behavioral patterns, large-scale log data presents an opportunity to learn which behavioral and contextual factors determine users' engagement with the system, and study how the manipulation of these variables changes user behavior. For example, Schwarz *et al.* [9] utilized behavioral signals such as body pose and gaze to predict users' intent to engage with the system.

Finally, users' logged interactions and movements alone are not enough when attempting to understand their intentions and subjective experiences. In addition to system events and interactions, contextual information is needed to identify the reasons behind the detected behaviors [4]. For example, experience sampling methods based on user-initiated audio and video capture could provide a privacy preserving method for supplementing the log data.

Conclusions

Large-scale log data collected in field studies and deployments present a rich yet challenging source for public display usage analysis. We believe that automated sequence detection and characterization techniques that are supported with interactive visualization could help analysts explore the interaction traces captured in situ, and the identified behavioral patterns could in turn inform the design of public display interactions.

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References

[1] Alt, F., Schneegaß, S., Schmidt, A., Müller, J., and Memarovic, N. 2012. How to evaluate public displays. In *Proc. PerDis '12*. ACM, Article 17.

[2] Fisher, C. and Sanderson, P. 1996. Exploratory sequential data analysis: exploring continuous observational data. *interactions 3*, 2, 25-34.

[3] Hilbert, D.M., and Redmiles, D.F. 2000. Extracting usability information from user interface events. *ACM Comput. Surv.* 32, 4, 384-421.

[4] Kim, J.H., Gunn, D.V., Schuh, E., Phillips, B., Pagulayan, R.J., and Wixon, D. 2008. Tracking real-time user experience (TRUE): a comprehensive instrumentation solution for complex systems. In *Proc. CHI '08*. ACM, 443-452.

[5] Mankowski, W.C., Bogunovich, P., Shokoufandeh, A., and Salvucci, D.D. 2009. Finding canonical behaviors in user protocols. In *Proc. CHI '09*. ACM, 1323-1326.

[6] Michelis, D., and Müller, J. 2011. The Audience Funnel: Observations of gesture based interaction with multiple large displays in a city center. *Int. J. Hum. Comput. Int. 27*, 6, 562-579.

[7] Moura, D., Seif el-Nasr, M., and Shaw, C.D. 2011. Visualizing and understanding players' behavior in video games: discovering patterns and supporting aggregation and comparison. In *ACM SIGGRAPH 2011 Game Papers*. ACM, Article 2.

[8] Müller, J., Bailly, G., Bossuyt, T., and Hillgren, N. 2014. MirrorTouch: Combining touch and mid-air gestures for public displays. In *Proc. MobileHCI '14.* ACM, 319-328.

[9] Schwarz, J., Marais, C.C., Leyvand, T., Hudson, S.E., and Mankoff, J. 2014. Combining body pose, gaze, and gesture to determine intention to interact in vision-based interfaces. In *Proc. CHI '14*. ACM, 3443-3452.

[10] Vogel, D., and Balakrishnan, R. 2004. Interactive public ambient displays: transitioning from implicit to explicit, public to personal, interaction with multiple users. In *Proc. UIST '04*. ACM, 137-146.

[11] Wallner, G., and Kriglstein, S. 2012. A spatiotemporal visualization approach for the analysis of gameplay data. In *Proc. CHI '12*. ACM, 1115-1124.

[12] Williamson, J.R., and Williamson, J. 2014. Analysing pedestrian traffic around public displays. In *Proc. PerDis '14*. ACM, 13-18.

Investigating the Effect of the Body's Spatial Representation on Gestural Interaction

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Abstract
Recent research has shown that the body provides an interactive surface suitable for eyes-free interaction. However, when relying on proprioception and kinesthesia alone, performing gestures on the surface of the body may not be universal among users. We argue that the way users perform gestures on the body depends on their body's spatial representation. This representation may also affect the perception of haptic feedbacks on the skin of the body. To demonstrate our argument, we report a study investigating gestures on the surface of the stomach. We then discuss how our results can also benefit to haptic output techniques and consider new research opportunities.

Author Keywords
Spatial body representation; Gestural interaction; On-body interaction; Haptic feedback

ACM Classification Keywords
H.5.2. User Interfaces — Input devices and strategies — Haptic I/O.

Introduction
On-body interaction provides an always available surface to support gestural interaction, especially in

mobile contexts. While most of the research in the HCI community has focused on designing new gestural interaction techniques driven by visual feedback, mobile context usually requires visual attention to be dedicated to maneuver our way around obstacles or avoid any potentially harmful situations. When the visual sense is unavailable, performing gestures relies on proprioception and kinesthesia alone. They provide users with information to build a mental representation of their body shape necessary to the coordination of their limbs. However, because of the dynamic nature of movements, the space configuration of the limbs can be unpredictable. In this paper, we investigate the potential effect of the limbs' spatial configuration on performing gestures on the body surface and on the perception of ultrasonic haptic feedback on the skin of the body.

We first present existing evidence of the effect of spatial body configuration on cutaneous stimuli perception. We then investigate the effect of spatial body representation on gestures with a study on perception on the surface of the stomach. We show that users follow different representations that are stable when using simple gestures such as directional strokes but more subject to change with more complex gestures such as drawing a digit's shape. We then discuss how our results suggest that the body's spatial representation may as well affect the perception of haptic feedbacks.

The Body's Spatial Representation

Cutaneous pattern perception depends on the position and the skin surface orientation. Parson *et al.* [4] have reported that the head, the upper body and the hands have different spatial frames of reference depending on their spatial configuration. In particular, the upper chest has special frames associated with it because it is a general zone for referencing information about objects in front of the body [4]. Previous experimental studies also report that the perception of spatial orientation relies on the internal gravity representation of the user and on perceptive information collected about the orientation of the surface supporting the interaction [3]. Interestingly, no rule governing the perception of orientation for vertical surfaces located below the chest has emerged.

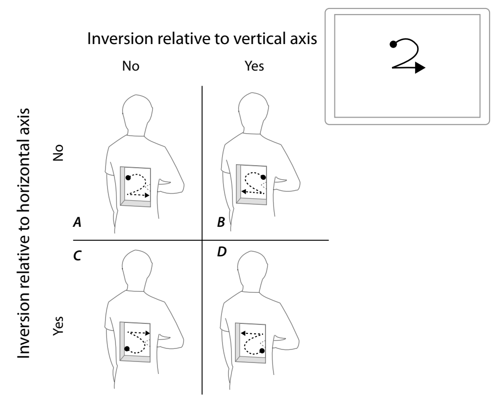

Figure 1. Spatial mental representations of the digit "2". The participant is facing the screen where the stimulus is displayed. A) No inversion. B) Inversion relative to vertical axis. C) Inversion relative to horizontal axis. D) Inversion relative to both axes.

On-Stomach Gestures

Without visual feedback, users need to build a spatial frame of reference that will guide them for controlling the orientations and the directions of the gestures. In order to understand how users perceive their stomach as an interactive surface, we invited participants to draw directions and digits on the surface of their stomach and observed the horizontal (towards the left or right side) and vertical directions (top or bottom) of the gestures to identify the internal user's spatial representation of their stomach surface (Figure 1).

We designed an experiment considering two factors: the *presentation* mode and the *nature* of the stimulus. The stimulus was either displayed graphically with directional cues facilitating its reproduction or textually without any information about how to draw it (Figure 2). The stimulus could either be a direction, which was considered as a simple gesture, or a digit, which we believe was more complex to draw and could affect the way the users would perceive spatial orientation.

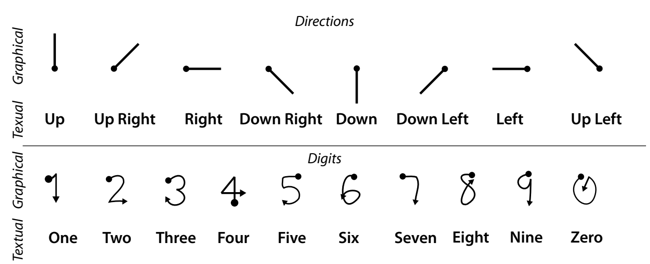

Figure 2. Graphical and textual stimuli used during the experiment.

By convention, we consider there is a "direct mapping" when the experimenter, located behind the participant, sees the symbol through the participant's stomach surface as depicted on the screen (Figure 1A). Three other mental representations are however possible depending on whether there is a horizontal (Figure 1B), vertical (Figure 1C), or horizontal and vertical (Figure 1D) inversion.

Twenty to 25% of the samples showed inversions relative to the horizontal axis whatever the experimental condition. This result is interesting since the psychology literature suggests that spatial representation of up/down direction is relative to the perception of gravity by the vestibular and somatic nervous system, and through sight [4]. These contradictory results can be explained by the mental representation of the spatial configuration of the body and the position of the head relative to the ground [4].

Our results additionally showed that the more complex the gesture, the less stable the orientation. Three of our participants changed their spatial mental representation over time when *digits* were presented *textually*. They emphasized the difficulty to select a unique representation: "*I tried to pay attention but for the digit 3 in particular I could not decide on an orientation. For digit 5 and 2, it was easier*".

The Effect of Spatial Body Representation on Gesture Learning

Recently, devices such as Ultrahaptics have made it possible to produce contactless haptic feedback on users' hands or body using ultrasounds [2]. Wilson *et al.* have shown that users are able to perceive motion of ultrasonic patterns on the skin of the hands [6]. In particular, participants could recognize the direction of movements towards the four cardinal points.

Building on these results, it is then conceivable to use such systems to support the learning and the execution of gestures on different parts of the body. For instance, with more complex haptic patterns, one could design feedforward techniques to draw a dynamic haptic pattern depicting the whole gesture on the skin of the body. The drawing could then be updated with the remaining path as the user is performing the gesture [1]. However, for this technique to work properly, the perception of the haptic patterns has to remain consistent through the different spatial configurations of the body part that is being targeted.

During the Wilson's experiment, participants experienced ultrasound haptic feedbacks on their hand with the palm facing up. Based on our results, we suggest that spatial representation of the body could also affect the spatial perception of haptic feedback that moves on the skin. The understanding of this phenomenon is necessary in order to provide correct and useful haptic feedbacks to users.

Conclusion & Research Agenda

We have discussed the effect of the body's spatial representation on gestural interaction. Our study has shown that users follow different representations that are stable when using simple gestures but more subject to change with more complex gestures. However, our study was limited to gestures performed on the abdominal surface. Spatial representations could be different when performing gestures on other limbs with different spatial configurations. Furthermore, while our research has only focused on input, we think that spatial representation of our body could also affect the perception of haptic feedback on the skin and thus the performance of promising output techniques to support gesture learning.

We plan to investigate the effect of spatial representation of other limbs on gestural interaction and moving haptic feedback. The ultimate objective is to draw a map of spatial representations of the body for each limb and propose a model of body spatial representation for on-body gestural interaction and haptic feedback on the skin.

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References

[1] Bau, O., & Mackay, W. E. (2008). OctoPocus: A Dynamic Guide for Learning Gesture-Based Command Sets. In *Proc. UIST 2008*, 37-46.

[2] Carter,T.,Seah,S.,Long,B.,Drinkwater,B.& Subramanian, S. UltraHaptics: Multi-Point Mid-Air Haptic Feedback for Touch Surfaces. In *Proc. UIST 2013*, 505-514.

[3] Gentaz, E., Baud-Bovy, G., and Luyat, M. The haptic perception of spatial orientations. In *Experimental brain research. 187*, 3 (2008), 331–48.

[4] Mergner, T. and Rosemeier, T. Interaction of vestibular, somatosensory and visual signals for postural control and motion perception under terrestrial and microgravity conditions--a conceptual model. In *Brain research. Brain research reviews 28*, 1-2 (1998), 118–35.

[5] Parsons, L.M. and Shimojo, S. Perceived spatial organization of cutaneous patterns on surfaces of the human body in various positions. In *Journal of experimental psychology: Human perception and performance 13*, 3 (1987), 488–504.

[6] Wilson, G., Carter, T., Subramanian, S., & Brewster, S. A. (2014). Perception of ultrasonic haptic feedback on the hand. In *Proc. CHI 2014*, 1133–1142.