Proceedings of

# Peripheral Interaction

## Shaping the Research and Design Space

Workshop at CHI2014, April 27th, Toronto, Canada

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Saskia Bakker, Doris Hausen, Ted Selker, Elise van den Hoven, Andreas Butz, Berry Eggen (Editors)
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# Peripheral Interaction: Shaping the Research and Design Space

**Saskia Bakker**
Industrial Design Department,
Eindhoven University of
Technology, the Netherlands
s.bakker@tue.nl

**Doris Hausen**
Human-Computer-Interaction
Group, University of Munich
(LMU), Germany
doris.hausen@ifi.lmu.de

**Ted Selker**
Carnegie Mellon University
Silicon Valley, CA, USA
ted.selker@sv.cmu.edu

**Elise van den Hoven** [1,2]
[1] Faculty of Design, Architecture
& Building, University of
Technology, Sydney, Australia
[2] Industrial Design Department,
Eindhoven University of
Technology, the Netherlands
elise.vandenhoven@uts.edu.au

**Andreas Butz**
Human-Computer-Interaction
Group, University of Munich
(LMU), Germany
andreas.butz@ifi.lmu.de

**Berry Eggen**
Industrial Design Department,
Eindhoven University of
Technology, the Netherlands
j.h.eggen@tue.nl



## Abstract
In everyday life, we are able to perform various activities simultaneously without consciously paying attention to them. For example, we can easily read a newspaper while drinking coffee. This latter activity takes place in our background or *periphery* of attention. Contrarily, interactions with computing technology usually require focused attention. With interactive technologies becoming increasingly present in the everyday environment, it is essential to explore how these technologies could be developed such that people can interact with them both in the focus and in the periphery of attention. This upcoming field of *Peripheral Interaction* aims to fluently embed interactive technology into everyday life. This workshop brings together researchers and practitioners from different disciplines to share research and design work and to further shape the field of *Peripheral Interaction*.

## Author Keywords
Peripheral interaction; human attention; trained routines; calm technology; ambient information; interaction design.

## ACM Classification Keywords
H5.2. Information interfaces and presentation: User interfaces, Interaction styles, User-centered design.

## Introduction
The presence of computing technologies in everything we do has rapidly increased over the past decades.

These technologies are often equipped with user interfaces such as keyboards and touchscreens, which typically require focused attention during interaction. Along with the many opportunities that come with this development, it also raises a challenge in the integration of technologies in our everyday routines. To address this challenge, several researchers [9,11,12] have been inspired by the observation that many interactions with the physical world take place in the background or *periphery* of attention. For example, we can easily tie our shoelaces while having a conversation or be aware or the approximate time while reading a book. These peripheral activities are performed in parallel to a different main activity.

The approach of employing the periphery of attention in human-computer interaction has been explored under various terms such as *calm technology* [12], *ambient information systems* [11] and *peripheral displays* [9]. While the majority of earlier work focused on background *perception* of information, we see an upcoming interest in background *interaction* with computing technology [2,3,5,6,10]. This workshop explores *Peripheral Interaction*, a direction which broadens the field by not only aiming to employ the *perceptual* periphery, but also to enable users to *physically interact* with the digital world in their periphery. Similar to everyday actions, Peripheral Interactions occur outside the focus of attention and fluently blend into everyday life.

This workshop follows up on a previous workshop [4], which focused on defining peripheral interaction and its key elements. These discussions raised opportunities to explore combinations of peripheral perception and action, to explore peripheral interfaces that frequently shift between focus and periphery and to question whether everything could potentially be a Peripheral Interaction. Having established a common ground and understanding of Peripheral Interaction, the proposed follow-up workshop focuses on how to operationalize Peripheral Interaction. By bringing together a variety of researchers and practitioners from a diversity of fields (e.g. computer science, interaction design, arts, psychology, product design, social science), we aim to further shape the field, work towards shared insights and yield future research and design on Peripheral Interaction. We invite people who see a challenge in better fitting interactive technologies into everyday life, whether or not their current work addresses Peripheral Interaction or related topics. More specifically, the workshop addresses the following questions:

*How to operationalize Peripheral Interaction?*
In recent years, a few interactive systems have been proposed in research literature, exploring physical interaction with computing technology outside the focus of attention. These systems were developed for various contexts such as the office [3,5,6], the home [10], the classroom [1,2], the car [4], and for interaction on the move [7,8]. This work furthermore explores several interaction styles, such as tangible interaction [3,5,6,10], gestures [4,6,7] and wearable devices [1,8]. While the body of related work is diverse, each of these examples can be seen as an initial exploration of Peripheral Interaction in the particular application area or with the particular interaction style under investigation. By bringing together a varying group of participants from both research and practice, we aim to discuss if and why particular application areas or interaction styles may be more suitable for Peripheral Interaction. This way, we hope to find connecting fields

of research in order to broaden and at the same time specify the scope of Peripheral Interaction research.

*How to integrate peripheral action and perception?*
While the majority of related work explored either *perception* of or physical *interaction* with digital information in the periphery, the combination of peripheral action and perception is relatively underexplored. Based on discussions at the preceding workshop [4], we see major potential in this combination. Peripheral feedback or feedforward [13] could for example support physical interactions in shifting to the periphery. Or physical interactions could be utilized to explore different layers in peripheral displays, which could increase their bandwidth. In this workshop, we will share and discuss theory on and examples of (potential) combinations of peripheral action and perception through presentations and demonstrations of participants. Additionally, we will moderate hands-on activities in which participants will conceptualize new interactive systems that explore variations of peripheral interfaces.

*How to facilitate shifts between center and periphery?*
The vision of employing the periphery of attention in interaction with technology was first introduced over 20 years ago, and indicated that such technology "engages both the center and periphery of our attention, and in fact moves back and forth between the two" [12:79]. While many researchers focus their studies on having perceptions or interactions take place in the periphery, it is often the moments when interactions shift between periphery and focus of attention, which are most beneficial to the user. Some literature is available on how to facilitate such shifts in peripheral displays [9], but this cannot easily be translated to physical Peripheral Interactions. Taking the participants' own experiences and examples as a starting point, the workshop will discuss strategies to facilitate interfaces in shifting between focus and periphery of attention.

## Workshop Goals
The workshop has the following main goals. (1) To build a community of researchers and practitioners with diverse backgrounds who are directly or indirectly working on Peripheral Interaction. (2) To share and discuss examples of Peripheral Interaction, in order to identify the scope of the research area. (3) To explore, hands-on, how various interaction styles, perceptual modalities and combinations of these can benefit Peripheral Interaction in order to connect different areas of research. (4) To build a classification and framework to guide research on Peripheral Interaction.

## Structure of the Workshop
*Before the workshop:* Potential participants submit a four-page position paper, directly or indirectly addressing the topic and goals of this workshop. Everyone is asked to include a description of their work and its relation to Peripheral Interaction. If feasible, participants may bring a demonstrator or video of their work, though this is by no means a requirement.

*During the workshop:* The workshop will start off with short, two-minute presentations of all participants, addressing points for discussion around Peripheral Interaction. Following, a "speed-date" session will be organized in which all participants informally get to know each other in short, two person conversations, by discussing the topics raised in the presentations. Before lunch, there will be a keynote of Albrecht Schmidt, who will share insights on creating seamless transitions between central and peripheral user interfaces. In the afternoon, the participants will engage in hands-on design-research activities in smaller groups. First they will develop conceptual designs, which explore various application areas, interaction styles and combinations of action and perception. Reflecting on these activities, the developed concepts will be enacted and experienced by all participants after a break, to elicit discussion on their success and the factors that contributed to this. The workshop will be wrapped-up by summarizing preliminary results related to the questions laid out above. The workshop is intended to lay the foundations for the operationalization of peripheral interaction and lead to future collaborations such as follow-up event and shared publications.

*After the workshop:* All accepted submissions will be included in dedicated workshop proceedings, published as technical report and on the workshop's webpage. This webpage will summarize outcomes of the workshop and host a blog on Peripheral Interaction, allowing participants to be involved in a community on Peripheral Interaction after the workshop. Provided that the quality of submissions allows it, we aim to set up a special issue on Peripheral Interaction, for which all participants will be invited to submit.

## References


[1] Bakker, S., van den Hoven, E., Eggen, B., and Overbeeke, K. Exploring peripheral interaction design for primary school teachers. *In Proc. TEI 2012*, ACM Press (2012), 245–252.

[2] Bakker, S., van den Hoven, E., and Eggen, B. FireFlies: physical peripheral interaction design for the everyday routine of primary school teachers. *In Proc. TEI 2013*, ACM Press (2013), 57–64.

[3] Edge, D. and Blackwell, A.F. Peripheral tangible interaction by analytic design. In *Proc. TEI 2009,* ACM Press (2009), 69–76.

[4] Hausen, D., Bakker, S., Hoven, E. van den, Butz, A., and Eggen, B. In *Proc. INTERACT 2013 workshop on Peripheral Interaction: Embedding HCI in Everyday Life.* www.peripheralinteraction.com (2013).

[5] Hausen, D., Boring, S., Lueling, C., Rodestock, S., and Butz, A. StaTube: facilitating state management in instant messaging systems. In *Proc. TEI 2012*, ACM Press (2012), 283–290.

[6] Hausen, D., Richter, H., Hemme, A., and Butz, A. Comparing Input Modalities for Peripheral Interaction: A Case Study on Peripheral Music Control. In *Proc INTERACT 2013*. Springer (2013), 162–179.

[7] Hudson, S.E., Harrison, C., Harrison, B., L., and LaMarca, A. Whack gestures: inexact and inattentive interaction with mobile devices. In *Proc. TEI 2010*, ACM Press (2010), 109–112.

[8] Loclair, C., Gustafson, S., and Baudisch, P. PinchWatch: A Wearable Device for One-Handed Microinteractions. In *Proc. Workshop 'Ensembles of On-Body Devices', MobileHCI 2010*.

[9] Matthews, T., Rattenbury, T., and Carter, S. Defining, designing, and evaluating peripheral displays: an analysis using activity theory. *Human-Computer Interact. 22*, 1 (2007), 221–261.

[10] Olivera, F., García-Herranz, M., Haya, P.A., and Llinás, P. Do Not Disturb: Physical Interfaces for Parallel Peripheral Interactions. In *Proc. INTERACT 2011*, Springer (2011), 479–486.

[11] Pousman, Z. and Stasko, J. A taxonomy of ambient information systems: four patterns of design. In *Proc. CHI 2006,* ACM Press (2006), 67–74.

[12] Weiser, M. and Brown, J.S. The Coming Age of Calm Technology. In *Beyond Calculation: the next fifty years of computing*. Springer-Verlag (1997), 75–85.

[13] Wensveen, S.A.G., Djajadiningrat, J.P., and Overbeeke, C.J. Interaction frogger: a design framework to couple action and function through feedback and feedforward. In *Proc. DIS 2004*, ACM Press (2004), 177–184.

# Potential in Thermal Sensations and Conceptual Metaphors for Peripheral Interaction

**David James Barter**
School of Interactive Arts and Technology
Graduate of Simon Fraser University
Surrey, B.C. Canada
david.barter@davidbarter.net

**Henry W.J. Lin**
School of Interactive Arts and Technology
Student of Simon Fraser University
Surrey, B.C. Canada
hwlin@sfu.ca


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## Abstract
We are a team consisting of an independent alumnus and a member of the Everyday Design Studio, each from Simon Fraser University. Our interest in the peripheral interaction field of research comes from our previous research on the perception of thermal sensations, and Conceptual Metaphor Theory. We have speculated that both thermal sensations and conceptual metaphors could facilitate effective peripheral interaction, particularly when in conjunction with each other. This is a conclusion we reached by assessing how each connects to the context of everyday practice, interaction over time, and meaning.

## Author Keywords
conceptual metaphor; interaction design; peripheral awareness; thermal sensation

## ACM Classification Keywords
H.5.2 User Interfaces: Interaction styles, H.5.2 User Interfaces: User-centered design

## Introduction
Peripheral *interaction* is a more complex attribute of our experience of the world than merely peripheral *awareness*. For interaction to occur peripherally, the

user's behaviour must change in some way, as a result of being affected by information perceived unconsciously. Their awareness must either remain peripheral during this change, or shift to central attention, if conscious processing becomes necessary.

This is in line with Saskia Bakker's recent thesis, *Design for Peripheral Interaction* [1], in which there is an investigation of factors that influence peripheral interaction, types of actions that occur in the periphery, and practical application scenarios of peripherally interactive systems. The study recognizes the importance of the everyday context and of *habituated activities* for peripheral interactions to take place. The content of the stimulus and the expectations of the individual allow for a natural ability to shift their attention on activities or information between central and peripheral awareness.

It is our intention to introduce some related concepts that may be applicable to peripheral behaviour changes, in terms of how they affect individuals' expectations, which have been raised in our own work. Our research has crossed between the disciplines of peripheral interaction [1, 7, 8], thermal sensations as an interpersonal communication medium [5, 6], and Conceptual Metaphor Theory [3, 4], in the course of investigating the potential of conceptual metaphors of thermal sensations [2].

We have followed up on our work on these studies to investigate how the concepts fit within the realm of peripheral interaction. Our research has found that thermal sensations are particularly well suited as a medium for peripheral awareness. The reason for this is that the attributes of temperature perception readily engage the periphery of users' attention. The perception of temperature is an everyday sensory experience that, in our studies, showed potential for consistent interpretation of meaning in specific contexts by the population at large [2]. This suggests that an interactive artifact that uses thermal sensations as feedback could be effectively interacted with in the periphery.

## Everyday Context of Thermal Sensations and Peripheral Interactions

The everyday context that has been discussed as the foundation of the reported peripheral experiences in Bakker's study [1] leads to the observation that our ability to process information unconsciously comes from how we learn starting from a very young age. As we experience and gain familiarity with the world, we develop *routines*, which readily become a part of our long-term memory. Routines are activities repeated many times in the same way, and thus become "activities in which one is very experienced and therefore do not require much thinking."  [1]. As such, to develop peripheral interaction design solutions and identify areas of opportunity in this field of study, we should focus on common types of experiences, exemplified in the peripheral activities that Bakker's participants revealed in their quotes [1].

Perception of temperature, according to Lee and Lim's study [5, 6] of the expressive potential of thermal sensations, falls into this category. In their post-interview findings, they noted that "[we] are already sensing and interpreting thermal sensations to get information about our environment, as well as setting expectations for what feeling a particular level of temperature in certain situations means." Participants in their studies consistently felt that there was a proper temperature for describing phenomena, objects and meanings [6]. This shows that there is a high level of pre-existing experience and expectation involved in perceiving temperature, and that should minimize the mental resources required for information processing and emerging behaviour changes.

### Interaction with Thermal Sensations over Time

In their study of *dynamic design elements* for peripheral interaction, Park and Nam [7, 8] point out the importance of the interactions occurring over time (4D design), and kinds of patterns that can be unconsciously perceived while this takes place. They define ambient media as being representative of giving weight to the periphery of our attention, being aware of our surroundings without attending to them explicitly, and having dynamic and temporal elements in order to do so.

The dynamic design elements themselves illustrate useful interaction patterns for peripheral systems that demonstrate the capability of managing different levels of importance, and the smooth and controlled shift of attention from peripheral to central and vice versa. In our considerations for the study we conducted to test users' perception of thermal sensations [2], we noticed that temperature could be readily presented using these design elements that, if given a separate main task, could have resulted in effective peripheral interaction. When the tempo, intensity, continuity or rhythm of a medium is designed to inform a user of something, it creates meaning in the interaction that they can "be aware of … at a glance, without attending to [it] explicitly." [7]

### Thermal Conceptual Metaphors Applied to Peripheral Interaction

Returning to the discussion of everyday context, we will now turn our attention to Conceptual Metaphor Theory (CMT). Introduced by Lakoff and Johnson [4], CMT proposes that human experience is metaphorical by nature, in that we readily make associations between things that are only loosely or subjectively tied together, and allow this abstract understanding of one concept in terms of another to give structure to our thought process. Conceptual metaphors begin with basic mappings between sensorimotor experiences, but eventually expand into image schemas, which are pre-conceptual structures based on early and recurrent experiences with the world [3].

Some simple examples involving temperature perception are: WARM is CLOSE, COOL is FAR (a measure of proximity that reflects how heat sources work in the real world) and WARM is SOFT, COOL is HARD (people think of melting butter, or expressions like "stone cold"). One of our findings during this process was that for temperature to work in metaphors with significant agreement on their meanings in terms of such concepts, they must be drawing on shared experiences or shared expectations of the meaning, in line with the everyday context necessary for peripheral interaction.

Furthermore, framing the interaction with a familiar metaphorical meaning can generate an awareness within expectations, and that awareness should remain peripheral as long as those expectations are met, minimizing the necessary mental resources to perceive what is happening. To initiate interaction beyond unconscious behaviour changes in response to what is perceived in this scenario, the shift to conscious attention to the system can be handled similarly to the pattern changes of the dynamic design elements: importance can be tied to a specific element or meaning, causing priming [1] to begin the shift, or importance can cause changes in the meaning that break the user's expectations and cause a shift.

## Conclusion

In this paper, we have combined several ideas from our studies on thermal conceptual metaphors, and from other sources, to put forward that thermal sensations are particularly well suited for a peripheral interaction context. With thermal sensations, common expectations within an everyday context can be leveraged because the perception of temperature is an everyday occurrence that carries metaphorical meanings.

We propose that interactions with thermal sensations should occur over time to engage the periphery, so that effective techniques such as establishing and changing the intensity, tempo, continuity and rhythm of what users feel during use can manage the attention level given to what is perceived.

Finally, our previous work on assessing the effectiveness of conceptual metaphors for thermal sensations shows that highly shared experiences and expectations can create an intuitive understanding of abstract concepts in terms of temperature or vice versa, which may use even fewer mental resources to perceive than an interaction rooted only in everyday practice.

The Peripheral Interaction workshop will be an excellent opportunity to begin clarifying where the use of thermal sensations and conceptual metaphors may ultimately fit into the realm of peripheral interaction, and how discussion with others in this research community may inspire the next phase in our work.

## References


[1] Bakker, S. Design for Peripheral Interaction, Eindhoven University of Technology (2013).

[2] Barter, D., Lin, H., Getting warmer: Identifying population stereotypes for thermal expression, In *Proc. TEI 2013* (2013).

[3] Hurtienne, J., Stößel, C., and Weber, K. Sad is heavy and happy is light: Population stereotypes of tangible object attributes, In *Proc. TEI 2009*, ACM Press (2009), 61-68.

[4] Lakoff, G. and Johnson, M., *Metaphors we live by*, University of Chicago Press, Chicago, (1980).

[5] Lee, W., Lim, YK., Thermo-message: exploring the potential of heat as a modality of peripheral expression, *Proc. CHI 2010*, ACM Press (2010), 4231-4236.

[6] Lee, W., Lim, YK., Explorative research on the heat as an expression medium: focused on interpersonal communication, *Personal and Ubiquitous Computing*, Springer-Verlag London Limited (2011).

[7] Park, J.Y. and Nam, T.J. Understanding Dynamic Design Elements for Information Representation of Ambient Media. In *Proc. IASDR07*, (2007)

[8] Park, J.Y. and Nam, T.J. Dynamic Design Elements for the Peripheral Interaction of Ambient Media. *Proc. CHI 2008*, ACM Press (2008), 3717-3722.

# A Model of Calm HCI

**John N A Brown**
Interactive Systems (ISYS),
Alpen-Adria-Universität (AAU)
Universitätsstraße 65-67
9020 Klagenfurt, Carinthia,
Austria, and
Centre Tecnològic de Recerca
per a la Dependència i la Vida
Autònoma (CETpD),
Universitat Politècnica de
Catalunya (UPC)
Rambla de l'Exposició, 59-69
08800 Vilanova i la Geltrú,
Catalonia, Spain
jna.brown@gmail.com

**Martin Hitz**
ISYS, AAU
Universitätsstraße 65-67
9020 Klagenfurt, Carinthia,
Austria
martin.hitz@aau.at

**Gerhard Leitner**
ISYS, AAU
Universitätsstraße 65-67
9020 Klagenfurt, Carinthia,
Austria
gerhard.leitner@aau.at

**Andreu Català Mallofré**
CETpD, UPC
Rambla de l'Exposició, 59-69
08800 Vilanova i la Geltrú,
Catalonia, Spain
andreu.catala@upc.edu


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## Abstract
We propose a model of human-computer interaction (HCI) that incorporates the Peripheral Interaction (PI) that is a requisite part of what Weiser and Brown called the most important aspect of Ubiquitous Computing: "Calm". Standing firmly on the shoulders of earlier models of interaction, the Brown-Hitz model provides a simplified, three-tiered input/output system illustrating reflexive, pre-attentive, and attentive components of natural human interaction. An example is provided to show how the model offers an improvement over earlier models.

## Author Keywords
Peripheral Interaction, Calm Technology, Anthropology-Based Computing

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

## Introduction
Calm Technology should allow users to assess new information peripherally, enabling them to decide whether to divert their attention and change their focus [2]. It is well understood that humans can process information in several different ways, using different parts of the brain and nervous system, depending on how it is presented to

them. Despite that understanding, models of HCI have focussed on deliberate, attentive interaction. To date there have been no models of HCI that could account or even allow for peripheral interaction. We believe such a model is the next logical step.

## Other Models of Interaction

Norman proposed a 4-step model of the Human Action Cycle. "Thus the full cycle of stages for a given interaction involves: executing the action; and evaluating the outcome." [8]. Many authors have tried to improve the model of HCI, by providing additional details.

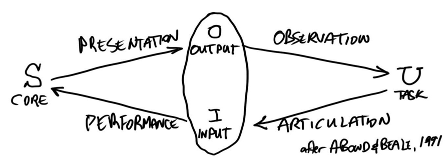


**Figure 1:** Abowd and Beale's translation-based mode

Abowd and Beale [1] provide a model that shows the incoming and outgoing actions on both the "human" and "machine" sides of an "interface" that is labeled with both "input" and "output" (redrawn in Figure 1). The four translations become the focus of this model in order to enable formal analysis of interface-based issues.

Mackenzie [6] simplifies the model, giving the reader three items on each side of the dotted line that represents the interface. The two directional items on either side of the line are now labeled in terms of computer use. The human's "motor responses" now exert actions on the computers "controls", and the computers "displays" feed into the human's "sensory stimulae". This is redrawn (with the components flipped horizontally in order to maintain a consistent direction across figures) in Figure 2.

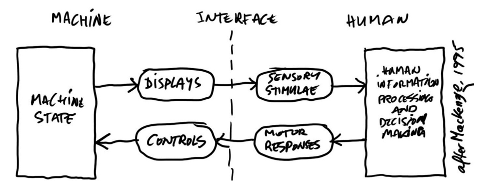


**Figure 2:** Mackenzie's simplified interaction model.

At APCHI, in 1998, Coomans and Achten introduced a more complex model, one that illustrates the processes between each action, labeling them with such descriptive terms as "thinking", "representing", "rendering", and "abstraction" (redrawn in Figure 3) [5]. This model gives some implicit value to the differences between human and

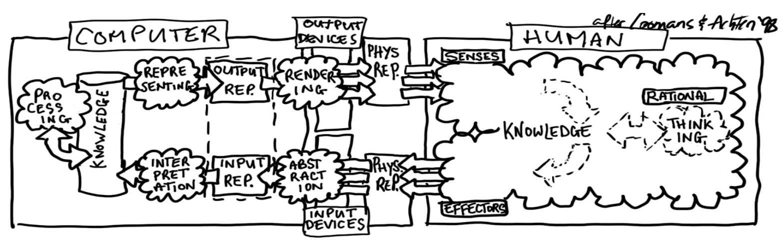


**Figure 3:** Cooman and Achten's Model

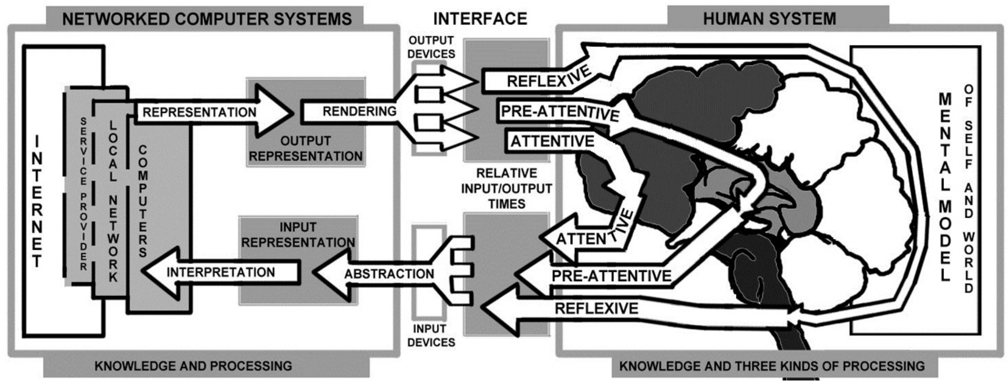


**Figure 4:** The Brown-Hitz model of interaction in which input and output can be processed at three different levels of attentiveness.

computer, telling us that computers use "processing" on "knowledge in internal digital representation", while humans conduct "rational thinking" using "knowledge" in an "internal mental representation". The other matters of note are the way in which input devices are used to "abstract" human intent from a physical representation into something that can be interpreted by the machine, while the output device renders the machine's "output representation" into a "physical representation" that can be perceived by the human's "senses".

This is a more human-centered model, with separate arrows for different kinds of "physical representations" that have been rendered and presented to the human, and separate arrows for the different kind of senses that might perceive these signals. It does the same for the human effectors, suggesting that there may be multiple separate channels of human output that could be driving computer input devices. Now that a model has proposed that humans and machines process information differently, and that humans deal with multiple, simultaneous streams of input and output, we will formalize the idea by illustrating the levels of attentiveness at which this happens.

We propose the Brown-Hitz model (Fig. 4) to illustrate the means by which multitasking and peripheral interaction take place, thus pointing towards the HCI modifications necessary to enable Calm Technology (CT). Based on the theory of "Anthropology-Based Computing" (ABC) [3], our model separates "attentive" interaction from the "pre-attentive" and "reflexive" information sensing and processing that take place elsewhere in the brain. This illustrates a natural aspect of human interaction with the world and suggests the possibility of deliberately-parallel input and output devices that would focus on one or the other of these sensing and processing modalities.

## Pop-Up or Fade-Up: An Illustrative Example

You are writing a paper and an email arrives in your inbox. The pop-up appears suddenly. As a result of a misunderstanding of the term periphery [4], it is likely that the pop-up has attracted your visual attention. Whether you try to close it or simply wait until it fades, you have already begun processing the text. Not only is the message not available for peripheral interaction, you are now thinking about it whether you wanted to or not.

Now imagine a signal designed to trigger only the pre-attentive portion of your sensory system so that you perceive subtle signals and recognise familiar patterns without interrupting attentive focus. Our "fade-up" has no text, just the image from the sender's profile. It appears quietly, fading up from fully transparent to partialy so and then fading out again right away. Unlike other systems, it never intrudes beyond the periphery [7]. Glancing at it is like glancing at a face passing by: you either recognise it or you don't. You decide whether or not to pursue more information, based on your own preferences at the time. Waiting for an important email from that sender? Click on the pop-up. Want to continue what you're doing without interruption? The pop-up is already gone and never interfered with your work. What's more, you have pre-attentively either recognised the image or recognised that some unknown icon has appeared. In either case, you have been informed - on the periphery - and you can go looking for more information if and when you choose to do so.

## Conclusions and Future Work

We are testing fade-ups and calm ringtones, but it is our hope that our model will have implications beyond HCI. It could be of great benefit in the field of Human Factors, with particularly important application to control systems in transportation and hazardous industries where human error is associated not only with stress but with incidents, accidents, and disastrous outcomes.

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## References

[1] Abowd, G., and Beale, R. Users, systems and interfaces: A unifying framework for interaction. *HCI 91* (1991), 73–87.

[2] Bakker, S., van den Hoven, E., and Eggen, B. Acting by hand: Informing interaction design for the periphery of peoples attention. *Interacting with Computers 24* (2012), 119–130.

[3] Brown, J. N. A. It's as easy as abc: Introducing anthropology-based computing. In *Advances in Computational Intelligence. Proceedings of IWANN 2013: The International Work-Conference on Artificial Neural Networks* (2013).

[4] Cadiz, J. J., Venolia, G. D., Jancke, G., and Gupta, A. Sideshow: Providing peripheral awareness of important information. Tech. rep., Microsoft Research, 2001.

[5] Coomans, M. K. D., and Achten, H. H. Mixed task domain representation in vr-dis. In *Proceedings of APCHI 1998: 3rd Asia Pacific Conference on Computer Human Interaction.* (1998).

[6] MacKenzie, I. S. *Virtual environments and advanced interface design*. Oxford University Press, 1995, ch. Input devices and interaction techniques for advanced computing., 437–470.

[7] Mueller, H., Kazakova, A., Pielot, M., Heuten, W., and Boll, S. Ambient timer. In *INTERACT 2013*, Springer (2013), 211–228.

[8] Norman, D. A. Stages and levels in human-machine interaction. *International Journal of Man-Machine Studies 21(4)* (1984), 365–375.

# A Measure of Calm

**John N A Brown**
Interactive Systems (ISYS),
Alpen-Adria-Universität (AAU)
Universitätsstraße 65-67
9020 Klagenfurt, Carinthia,
Austria
jna.brown@gmail.com

**Gerhard Leitner**
ISYS, AAU
Universitätsstraße 65-67
9020 Klagenfurt, Carinthia,
Austria
gerhard.leitner@aau.at

**P S Bayerl**
Rotterdam School of
Management, Erasmus
University
Burgemeester Oudlaan 50
3062 PA Rotterdam,
Holland-Zuid, Netherlands
pbayerl@composite.rsm.nl

**Andreu Català Mallofré**
CETpD, Universitat Politècnica
de Catalunya
Rambla de l'Exposició, 59-69
08800 Vilanova i la Geltrú,
Catalonia, Spain
andreu.catala@upc.edu

**Anton Fercher**
ISYS, AAU
Universitätsstraße 65-67
9020 Klagenfurt, Carinthia,
Austria
antonjosef.fercher@aau.at

**Martin Hitz**
ISYS, AAU
Universitätsstraße 65-67
9020 Klagenfurt, Carinthia,
Austria
martin.hitz@aau.at


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## Abstract
We propose the prototype of a quantitative metric for evaluating whether or not a piece of technology is "Calm". Our approach is based on Weiser's vision of Calm Technology (CT) and on the principles of Anthropology-Based Computing (ABC) and Peripheral Interaction (PI). Our hope is to derive feedback from this workshop that will allow us to further develop our metric as a tool for use in the fields of HCI, Design, and Human Factors.

## Author Keywords
Metrics, Calm Technology, Peripheral Interaction, Anthropology-Based Computing

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

## Introduction
Calm Technology (CT) describes any tool that can be used with uninterrupted focus on a central task while new outside information is perceived and processed peripherally. This dynamic allows the user to decide whether to divert their attention and change their focus at any time, providing a cycle of perceptual feedback and response similar to the cortical discharge cycle by which all animals interact with their environment [4].These iterative

cycles of perception, evaluation, and reaction have shaped our evolution and continue to shape our understanding of, and interaction with, the world around us.

Even though the idea of "Calm" was introduced into HCI nearly twenty years ago [7], it is still not quantified. To help realize the promise of "Calm", we propose the development of a simple quantitative metric based on an understanding of how humans perceive, process, and respond to environmental stiumulii.

## Anthropology-Based Computing (ABC)

ABC is based in part on the fact that the human animal perceives and processes data in certain specific ways [3]. Our model generalizes them into three progressive categories, each named for a part of the brain.

1) The medulla oblongata represents *reflexive* responses to sub-cerebral stimuli, like pulling your hand away from a flame or squinting when a continued noise is too loud. This part of the brain is where we knit and walk and chew. One HCI example is a cursor forcefield providing subtle haptic feedback [1]. If the interaction is inconsistent or surprising then it will trigger a higher level of attention.

2) The amygdala represents *pre-attentive* responses to familiar patterns of sight or sound or motion. This is where we perform familiar tasks like typing a pre-written phrase, tying our shoe-laces, and turning off the lights as we leave a room. A HCI example is clicking recognised software pop-ups to close them without reading them carefully. If a pop-up is inconsistent or surprising, the pattern change will trigger a higher level of interaction.

3) The prefrontal cortex represents *attentive* thought. A pattern that cannot be easily recognised pre-attentively is referred to the prefrontal cortex for deeper analysis. For example, this is where I am writing this paper, and it is where you are reading it. There is no higher level of attention to go to if another task arises to make additional demands on your *attentive* system. This means that your attention will now have to be divided.

## Peripheral Interaction (PI)

PI usually describes the perception, processing and reactions that take place on the edge of our attention [2]. Our understanding of PI is based on the fact that while we are attending to a task in any one of the three attentional categories given above, we can still perceive, process, and act on information in either of the other two. A caveat is that tool use or task performance, singly or in combination, is only "Calm" if the user can, at any time, receive, process, and react to peripheral information.This is an important distinction. A prolonged *attentive* task may lead one into "flow" [5] where performance is improved but peripheral perception becomes narrowed or even disappears. When that happens, our *pre-attentive* processors create false patterns to fill in the blanks. You may feel calm when you are working deeply at a task, lost in the flow of coding or painting or some equally-immersive task, but that does not mean the task is "Calm". In fact, getting so lost in a task that you cannot perform any PI can be very dangerous.

*Some thoughts on context, task switching and multitasking*
A wall clock is a perfectly "Calm" technology. To begin with, the technology is transparent. You are looking at the clock but you are seeing the time. The clock does not demand any attention at all when it is not being used. When it is used, a glance should be enough to recognise one of the limited instances of a known pattern that could reflect the current time. This recognition will happen pre-attentively and will not interfere at all with any

*attentive* process happening elsewhere in the brain, or with any purely *reflexive* processes, either. Of course, this is only true if you know how to read a clock. We can conclude from this that knowledge can have an effect on "Calm". We can infer more mitigating factors.

A siren will not affect you as strongly if you hear it pass by in the distance as it will if it is right behind you: location affects "Calm".

If you are involved in a very focussed, all-consuming task like, say, giving birth, you may not even notice the siren at all: priority affects "Calm".

Continuosly patting yourself on the head with a gentle up and down motion of one hand is not, for most of us, a challenging task... for the first few minutes: fatigue and/or boredom affect "Calm".

The continuous patting becomes more difficult with the addition of an unrelated task for the other hand: multitasking affects "Calm".

This is even true of multitasking across modalities. Singing is more difficult while patting your head, unless you match the rhythm of the one to the other.

## The Metric

As a first usable step towards a quantitative measure of "Calm", we propose matrices which identify the *reflexive*, *pre-attentive*, and *attentive* demands of a task or tool. As shown in Figure 1, one plots the type of attentional demand required during each element of performance. We suggest that starting a task may be attentionally different that performing it in "flow". We also suggest that there may be attentional differences in pausing, resuming and stopping a task. Finally, we insist that any tool or task requires attention in a "worst case" scenario. The matrix for interuptive signals or alarms is shown in Figure 2.

| Classification of Attenional demands in a Layered Matrix | | | |
|---|---|---|---|
| **ELEMENTS** | **DEMANDS** | | |
| | REFLEXIVE | PRE-ATTENTIVE | ATTENTIVE |
| START | | | |
| FLOW | | | |
| PAUSE | | | |
| RESUME | | | |
| STOP | | | |
| **WORST CASE** | | | |

**Figure 1:** CALMatrix for evaluating tools and tasks

We offer the example of "driving", which involves continuous processing that is both *reflexive* (haptic and optic) and *pre-attentive* (recognising signs and markers, distances, movement patterns). Furthermore, because driving has potentially catastrophic consequences, the driver must always be ready to respond immediately with full attention, in a "worst case" scenario.

| CALMatrix for Signals and Alarms | | | |
|---|---|---|---|
| **RESPONSES** | **DEMANDS** | | |
| | REFLEXIVE | PRE-ATTENTIVE | ATTENTIVE |
| PERCEIVE | | | |
| PROCESS | | | |
| DELAY (snooze) | | | |
| DENY | | | |
| ACCEPT | | | |
| **IGNORE** | | | |

**Figure 2:** CALMatrix for evaluating signals and alarms

Once matrices have been filled in, different tasks can then be compared to see if it is safe to perform them at the same time. In this way we can see that it is not safe to combine driving and texting. Both demand *attentive* processing at all times and both are susceptible to the unwitting loss of peripheral perception. "Multitasking" might feel safe, but that is due to diminished attention to the periphery, not to diminished risk.

A final caveat: learning requires *attentive* processing, even when the task will eventually be performed *reflexively*, like walking or *pre-attentively*, like speed chess.

## The Act of Proposing Such Measures...

It may not be possible to achieve a universally-accepted measure of Weiser's "Calm", but we hope there is some value in the attempt. Fenton and Pfleeger [6] wrote: "Even when it is not clear how we might measure an attribute, the act of proposing such measures will open a debate that leads to greater understanding."

Today, we would like to open the debate on whether or not it is possible to quantitatively measure "Calm".

| Simple Hazard Identification through the Evaluation of Layered Displays | | |
|---|---|---|
| INTERRUPTIVE EVENT | Possible? Y/N | REMEDIAL ACTIONS (PRE- & POST-) |
| MINOR DISTRACTION | | |
| MAJOR DISTRACTION | | |
| PHYSICAL BREAK | | |
| MENTAL BREAK | | |
| TOOL FAILURE | | |

**Figure 3:** Prototypical "S.H.I.E.L.D." risk evaluation matrix

## Keep Calm and Carry On

We are currently testing "Calm" ringtones and a "Calm" replacement for pop-up messages and trying to further develop our "Measure of Calm". It is our hope that an accepted quantitative metric and the related improved understanding of peripheral interaction will not only improve the day-to-day experience of ubiquitous computing, but will lead to the acceptance of a metric like the one shown in Figure 3 to help Ergonomists and Human Factors Specialists mitigate the dangers in high-risk fields.


## Acknowledgments

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## References


[1] Ahlström, D., Alexandrowicz, R., and Hitz, M. Improving menu interaction: A comparison of standard, force enhanced and jumping menus. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (2006).

[2] Bakker, S., van den Hoven, E., and Eggen, B. Design for the periphery. In *Proceedings of the Eurohaptics 2010 Symposium Haptic and Audio-Visual Stimuli: Enhancing Experiences and Interaction* (2010).

[3] Brown, J. N. A. It's as easy as abc: Introducing anthropology-based computing. In *Advances in Computational Intelligence. Proceedings of IWANN 2013: The International Work-Conference on Artificial Neural Networks* (2013).

[4] Crapse, T. B., and Sommer, M. A. Corollary discharge across the animal kingdom. *Nature Reviews Neuroscience 9(8)* (2008), 587–600.

[5] Csikszentmihalyi, M., and Bennett, S. An exploratory model of play. *American Anthropologist 73(1)* (1971), 45–58.

[6] Fenton, N. E., and Pfleeger, S. L. *Software metrics: a rigorous and practical approach*. PWS Publishing Co., 1998.

[7] Weiser, M., and Brown, J. S. Designing calm technology. *PowerGrid Journal 1(1)* (1996), 75–85.

# PAINLEsS – Personalized Multimodal Persuasive Ambient and Peripheral Interaction for Information Security

**Marc Busch**
CURE – Center for Usability Research & Engineering
1110 Vienna, Austria
busch@cure.at

**Peter Wolkerstorfer**
CURE – Center for Usability Research & Engineering
1110 Vienna, Austria
wolkerstorfer@cure.at

**Christina Hochleitner**
CURE – Center for Usability Research & Engineering
1110 Vienna, Austria
hochleitner@cure.at

**Manfred Tscheligi**
University of Salzburg
5020 Salzburg, Austria
manfred.tscheligi@sbg.ac.at
&
AIT – Austrian Institute of Technology GmbH
1220 Vienna, Austria
manfred.tscheligi@ait.ac.at



## Abstract
Violations against information security policies in organizations caused by employees are frequent and expensive. Classical countermeasures, such as security training and education, as well as awareness campaigns only have a limited and short-term effect on the employees' information security policy attitudes and compliance. Additionally, they are time-consuming, expensive and don't comply with employees hedonic needs. To promote a positive and long-lasting increase of information security policy awareness and compliance we propose an innovative framework (PAINLEsS), which can be implemented in organizations and consists of sensors that detect violations against security policies and multimodal peripheral feedback, which educates users and raises awareness about/for secure behavior via personalized persuasive ambient strategies.

## Author Keywords
Information Security Policies; Security Training/Education/Awareness; Multimodal Ambient/Peripheral Interaction; Persuasion

## ACM Classification Keywords
H.1.2 User/Machine Systems: Human factor

## Introduction

According to a PWC survey[1] in the United Kingdom, 93% large and 87% small organizations had a security breach in the last year. These numbers have increased from year to year. Not only external attackers cause these security breaches: 36% of the worst security breaches in a year were caused by human error of the organization's employees. Neither technological approaches, nor human approaches (security education, training and awareness programs [SETA]) alone have been really successful: Employees know how to avoid technological approaches and SETA programs are obtrusive, time-consuming, and expensive, not directly in the context of information security breaches and have only short-term effects or must be administered repeatedly to have long-term effects. Additionally, they often don't contribute to a positive experience with information security compliance. Furthermore, employees are not aware of SETA programs or do not feel the wish to participate in such [7]. SETA programs are designed as a "one fits all" model, neglecting individual differences between employees.

## The Way Forward: PAINLEsS

Therefore, we propose an innovative framework that incorporates all these requirements and makes use of personalized persuasive peripheral and ambient feedback strategies. The goal is to change the employees' information security behavior through subtle peripheral cues. We believe that such cues provided through different modalities have the potential to persuade users towards this goal.

[1] http://www.pwc.co.uk/assets/pdf/cyber-security-2013-exec-summary.pdf

PAINLEsS (Personalized Multimodal Persuasive Ambient INtelligEnce for Information Security at the Workplace) will make use of different hard- and software sensors to provide contextual information to a security policy monitoring and alerting system. The sensor data is processed along with the security policies to detect breaches of those. Security breaches within the PAINLEsS framework refer to breaches (of the security policies) from employees (not from unauthorized outsiders). An example is the storage of unencrypted organizational data on the employees' mobile devices. From a breach of the security policies follows a personalized, multimodal, ambient and peripheral feedback about the user's security behavior. Sensor data includes lighting conditions, pressure sensors on the seating areas of chairs, but also cameras (to capture emotional reactions to personalize the systems' effectiveness).

The tailored multimodal and subliminal messages consist of visual cues, tactile stimulation, sound and scent - an underused modality in HCI [6]. Through the sensors' contextual data PAINLEsS will learn about (combinations) of subliminal messages that have a positive impact on security behavior. We hope to overcome the shortfalls of more cognitive and central approaches (e.g. technological and SETA approaches) with PAINLEsS and provide a holistic and positive information security experience to employees.

## The Concepts of PAINLEsS

Personalized Persuasive Technology is technology that aims at changing user attitudes and behavior towards in a certain domain (e.g. corporate information security) [2] by the implementation of a variety of persuasive strategies, e.g. by self-monitoring (help the user to keep track of performance, status or goal achievements) and is tailored to the users' individual personality [1,5]. Persuasive Technology has been rarely used in the area of information security [10]. Environmental Persuasion is persuasion that aims at a more unconscious persuasion that comes from the environment. For example: [8] suggests to implement a translucent digital interface as stairs in a subway to persuade people to take the stairs instead of an escalator. Environmental Persuasion is strongly related to Peripheral and Ambient Interactions. These are interactions with technology, which occur outside the central focus of the attention and fluently blend into everyday life.

### The PAINLEsS workplace

Our general approach is to overcome the utilitarian and more productivity-oriented notion of information security and increase compliance through hedonism [4]: users want to avoid unpleasant situations. Hence we expect them to behave in a way to change unpleasant situations back to pleasant ones and to be motivated through positive experiences.

Inspired by translucent stairs in a subway to promote stair climbing [8], employees have translucent writing desks, which can gradually change color from pleasant to unpleasant colors according to their security policy compliance. Not only the desks will change color, also parts of the employee's clothing will indicate security breaches [9]. Employees will be interviewed and observed to find out which color has positive/negative connotations to them to really personalize the experience. [3] have shown that lamps that gradually change color can be more effective in persuasion than factual feedback. The persuading factor, as we hypothesize, is the color: users will try to get back to a pleasant color and get rid of the more unpleasant color. PAINLEsS adapts methods for vibro-tactile [11] feedback originally used for seated posture guidance and develops an office chair, which informs users in about security breaches: Through vibration, thermal changes and movement. Over time, the PAINLEsS framework is able to learn about the user's behavior and can apply a range of personalized feedback combinations. For scent as feedback, PAINLEsS will learn through the analysis of the combination security breach and sensor data, which scents evoke positive/negative behavior. PAINLEsS will create an ambient soundscape which can also range from pleasant to unpleasant and changes according to security breaches. The soundscape will be chosen from a set of possible sounds, based on user preferences.

We see peripheral and ambient interaction and feedback at the workplace as a possibility to enhance the employees' experience in a positive way and to engage users in a hedonic way to comply with security policies. Our position is, that the personalized combination of different peripheral and ambient feedback modalities has a strong persuasive effect on the employees: Tailored light, tactile stimulation, scent, and sound are able to evoke strong emotions in the employees. We believe that the integration of emotions (through the described subliminal feedback) to promote security policy compliant behavior (detected by the security monitoring system) will be more effective than more cognitive and direct approaches (such as security trainings and awareness campaigns). The ongoing unobtrusive peripheral feedback is expected to have more influence than factual (e.g., security-warning pop-up windows on a screen) security feedback.

Unobtrusiveness and the lack of paternalisation are the user-experience factors, which make us believe, that our solution will have more impact than the classical SETA approach. We also believe that the presence of the security feedback (which is subtle, but lasting as long as user behavior changes) tends to increase the user's curiosity about his/her own behavior. We expect that in order to gain positive and hedonic experiences, users will be motivated to change the modalities that are provided by their workspace (e.g. light, scent) into comfortable states and learn to comply with security policies. However, these modalities also depend on the context and preferences may change over time.

## Discussion and Future Research

A limitation and crucial point in the PAINLEsS framework are certainly the legal and ethical implications: The nature of peripheral and ambient interaction at the workplace exposes the employees' security behavior to other employees and also to superiors. This is a fundamental intervention into personal privacy and has to be considered in the design of the framework. The framework should not blame or expose employees in front of their colleagues. In the future, we will conduct user research to examine if every component of the PAINLeSs framework is effective at raising security awareness and behavior and how it should be personalized. Then we will implement a first prototype in a company and evaluate it in a field study.


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## References


1. Busch, M., Schrammel, J., and Tscheligi, M. Personalized Persuasive Technology – Development and Validation of Scales for Measuring Persuadability. In *Persuasive Technology*. Springer Berlin Heidelberg, 2013, 33–38.
2. Fogg, B.J. *Persuasive Technology - Using Computers to Change What We Think and Do*. Morgan Kaufmann, 2002.
3. Ham, J., Midden, C., Maan, S., and Merkus, B. Persuasive lighting: The influence of feedback through lighting on energy conservation behavior. (2009).
4. Heijden, H. Van der. User acceptance of hedonic information systems. *MIS quarterly 28*, 4 (2004), 695–704.
5. Kaptein, M.C. Personalized persuasion in Ambient Intelligence. *Journal of Ambient Intelligence and Smart Environments*, (2012).
6. Kaye, J. "Jofish." Making Scents. *interactions 11*, 1 (2004), 48–61.
7. Lebek, B., Uffen, J., Breitner, M.H., Neumann, M., and Hohler, B. Employees' Information Security Awareness and Behavior: A Literature Review. *2013 46th Hawaii International Conference on System Sciences*, IEEE (2013), 2978–2987.
8. Mathew, A.P. Using the environment as an interactive interface to motivate positive behavior change in a subway station. *CHI '05 extended abstracts on Human factors in computing systems - CHI '05*, (2005), 1637.
9. Wakita, A. and Shibutani, M. Mosaic textile: wearable ambient display with non-emissive color-changing modules. *CHI'06* , (2006).
10. Yeo, A., Rahim, M., and Ren, Y. Use of Persuasive technology to change end user's IT security aware behavior: a pilot study. *International Journal of Human and Social Sciences*, (2009), 673–679.
11. Zheng, Y. and Morrell, J. Comparison of Visual and Vibrotactile Feedback Methods for Seated Posture Guidance. (2012).

# Managing Peripheral Interactions in Emergency Response Environments


**Apoorve Chokshi**
Department of Computer Science
University of Calgary
2500 University Dr. NW
Calgary, Alberta, T2N 1N4
apoorve.chokshi@ucalgary.ca

**Teddy Seyed**
Department of Computer Science
University of Calgary
2500 University Dr. NW
Calgary, Alberta, T2N 1N4
teddy.seyed@ucalgary.ca

**Francisco Marinho Rodrigues**
Department of Computer Science
University of Calgary
2500 University Dr. NW
Calgary, Alberta, T2N 1N4
fm.rodrigues@ucalgary.ca

**Frank Maurer**
Department of Computer Science
University of Calgary
2500 University Dr. NW
Calgary, Alberta, T2N 1N4
frank.maurer@ucalgary.ca





## Abstract

In this paper, we discuss how personnel in emergency operation centres (EOC) use peripheral interactions in the context of emergency response planning where multiple devices are concurrently updated with information from different sources both from inside and outside the EOC. We present ePlan Multi-Surface, our multi-surface prototype for emergency response planning which relies on the use of different devices and peripheral interactions to manage information during emergency response planning. We also present our research questions on the direction of peripheral interactions in emergency response planning.



## Author Keywords

Emergency Response Planning; Multi-surface environments; Peripheral Interactions

## ACM Classification Keywords

H.5.2 [Information interfaces and presentation]: User Interfaces— Input Devices and Strategies; Interaction Styles.


## Introduction

EOCs from governments and the private sector rely on information from numerous sources when conducting emergency response planning and when dealing with a live event. These sources may include their own personnel (e.g. firefighters, police, emergency medical services (EMS), or armed forces), or third-party sources (e.g. news channels or citizens) that use different protocols before exchanging information.

The source of information determines whether it enters the EOC via video, audio, or text. A traffic or incident camera could live-stream into the EOC, tweets could arrive via text, and information from ground-personnel may arrive via text messages or by word-of-mouth. EOC personnel need to ascertain the importance, authenticity, and accuracy of the information as device screens update. Emergency personnel report through their chain-of-command, reporters (print, television and radio) have their information fact-checked before broadcast, while citizens may live-tweet, post, or send emails while the event unfolds. When the EOC receives these information updates from the three sources (their personnel, reporters, or citizens), they also need to peripherally monitor developing traffic congestion, incident cameras, and operational decisions that are being updated on a large wall display.

Multi-surface environments (MSE) provide an environment amenable to emergency response planning and peripheral interactions by separating and segmenting areas for information triage. For example, iPads are personal workspaces from which personnel can privately communicate with colleagues, tabletops serve as a collaboration and cooperation area, and large wall displays can aggregate information from multiple sources – movement of personnel, traffic and incident cameras, and tweets.

## Related Work

Detecting and monitoring emergencies and managing the deployment of resources and communication are important tasks in emergency response planning [1]. Emergency response planning is inherently a peripheral process [2], as critical information about an emergency can arrive from numerous sources (e.g. first responders, reporters, or online sources) and information processing and analysis are typically done in parallel with the primary emergency response-planning task [2] typically with interruptions [3]. In the research literature, emergency response planning is a well-explored area, with several different technologies (e.g. tabletops [1]) being used to assist in these tasks, as well as information management, collaboration, and efficiency [4].

While many of these systems utilize single tabletops or other devices and show immediate benefit in emergency response situations [1], they do not properly consider peripheral interaction scenarios (e.g. multiple-users interacting with each other on tabletops, who may also be concurrently analyzing or receiving different sources of information) in emergency response planning situations. This may be due to interface design or physical constraints such as orientation or screen size. This gap provides an opportunity for exploration in using MSE – environments containing multiple heterogeneous devices (e.g. tablets, wall displays, tabletops) – which allow for a variety of different tasks and interactions (e.g. “flicking” to different screens) [5]. Leveraging the concepts of MSE and their interactions in emergency response planning and its peripheral nature provides the basis for our preliminary implementation of ePlan Multi-Surface that we present in this paper.

## ePlan Multi-Surface Design


**Figure 1.** *ePlan Multi-Surface* Emergency Response (a) A digital tabletop is used as the hub of communication and collaboration. (b) A large high-resolution wall display provides an overview of the emergency situation and contains information updates for which all EOC personnel are required to be aware. (c) A personal laptop is used as a private workspace (in addition to digital tablets). (d) A Microsoft Kinect is used to track users to facilitate multi-surface interactions such as flicking and pouring.

In collaboration with an emergency response simulation software company, C4i Consultants Inc.[1], located in Calgary, Alberta, Canada, we designed *ePlan Multi-Surface* Emergency Response. As shown in Figure 1, the environment consists of a large high-resolution wall display, digital tabletop, Microsoft Kinect, a personal laptop and multiple iPads (not displayed). The system was built using C4i's ePlan desktop software to drive the emergency simulation, as well as MSE-API [6], which provides inter-device communication and multi-surface interactions.

### Peripheral Multi-Surface Interactions

To highlight the role of peripheral interactions in our multi-surface prototype, we will describe the typical usage scenario during an emergency response-planning scenario used by our industry partner:

**Step 1: *Emergency Alert Issued.*** In the first stage, the emergency response operation controller receives information in different mediums (text, email, and phone) from various sources (fire, EMS, and police) about an emergency. The EOC then determines the type of emergency that is occurring and issues a state of emergency to a city or municipality. During this time, EOC personnel are continually receiving and analyzing information on their iPads, in addition to analyzing the situation globally on the large wall display that showcases information from live traffic and incident cameras, and Twitter. The EOC is often interrupted or doing tasks simultaneously due to the evolving nature of an emergency.

**Step 2: *Response Representatives Assemble.*** After the alert has been issued, the response personnel assemble in the *ePlan* multi-surface emergency response-planning environment. Depending upon the severity of the event, these representatives may include the fire department, EMS, and police. Representatives have iPads containing relevant information that is either shared at their discretion or used in their own assessment for allocating their resources during the emergency. Representatives can share information from their iPads using gestures (one or two-finger flicks, or a pour gesture) to send information to other devices in the room (wall display, tabletops, or iPads). The wall display allows everyone in the room to see the information; the tabletop is used to assist in collaborative emergency response planning; or other iPads are used to facilitate communication between different representatives. These multi-surface interactions are typically done in parallel with planning or analysis tasks in the EOC, and visual notifications that can been seen in the user's periphery are used to prompt representatives when new data arrives on a device. Also, since there are many representatives in EOC, it is possible to peripherally see someone using gestures when sharing new or updated information.

**Step 3: *Emergency Response Planning.*** During the emergency response-planning scenario, which lasts

[1] http://www.c4ic.com/

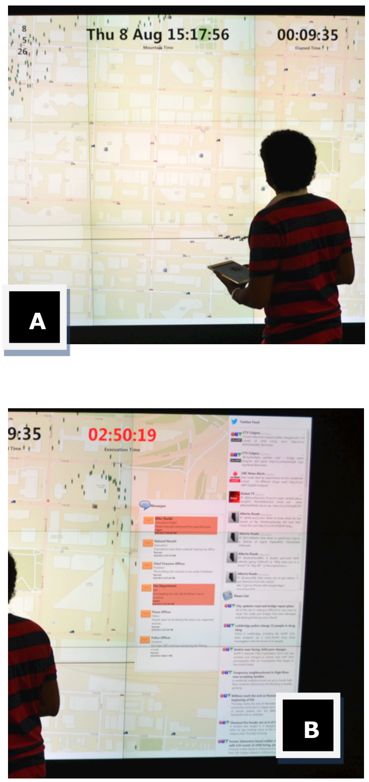


**Figure 2.** Example of peripheral interaction in ePlan. (a) An EOC personnel is examining the overview map of an emergency on a large wall display (b) The EOC personnel must also be peripherally aware of live twitter, messages and news

until the end of an emergency situation, numerous types of interactions occur. This session is the most critical component of emergency response planning, as significant coordination and planning are done. In *ePlan* multi-surface, emergency response personnel are continually collaborating and consuming new information rapidly using iPads, while also simultaneously trying to keep track and manage the emergency through the wall display and digital tabletop. At the end of an emergency response-planning scenario, a report is typically generated that summarizes the emergency and the contributions of the emergency response representatives.

## Discussion

In this work, we have presented our multi-surface emergency response-planning prototype, *ePlan Multi-Surface*, and have discussed the role of peripheral interactions. In particular, we highlighted the information hierarchy in emergency response planning situations that were incorporated into the prototype and impact the peripheral interactions in the EOC. Overall, feedback from preliminary discussions with personnel from the Alberta Emergency Management Agency has been positive; however, one common theme in their feedback has been a request for consideration of paper-based interactions. This leads to an interesting question of the consideration of mixed-fidelity peripheral interactions in emergency response planning and their role in the design of multi-surface interactions. We plan to explore the following research questions in our next prototypes:

- How do we incorporate hierarchy in the design of peripheral interactions for multi-surface environments?
- How scalable are peripheral interactions for multi-surface environments, and what types of devices are more amenable to them?
- Are multi-surface interactions a viable solution to managing peripheral interactions in emergency response situations and other application scenarios?

## References

[1] Bortolaso, C., Oskamp, Matthew, Graham, N., and Brown, D. OrMiS: a tabletop interface for simulation-based training. In Proceedings of the 2013 ACM international conference on Interactive tabletops and surfaces (ITS'13) (St. Andrews, Scotland, UK 2013).

[2] Bakker, S., van den Hoven, E., and Eggen, B. Design for the Periphery. In Proceedings of the Eurohaptics 2010 Symposium Haptic and Audio-Visual Stimuli: Enhancing Experiences and Interaction (Amsterdam, The Netherlands 2010).

[3] Edge, D. and Blackwell, A.F. Peripheral tangible interaction by analytic design. In Proceedings of the 3rd International Conference on Tangible and Embedded Interaction (TEI'09) (Cambridge, United Kingdom 2009).

[4] Hofstra, H., Scholten, H., Zlatanova, S., and Alessandra, S. Multi-user tangible interfaces for effective decision-making in disaster management. In Remote Sensing and GIS Technologies for Monitoring and Prediction of Disasters. Springer Berlin Heidelberg, 2008.

[5] Seyed, T., Burns, C., Costa Sousa, M., Maurer, F., and Tang, A. Eliciting usable gestures for multi-display environments. In Proceedings of the 2012 ACM international conference on Interactive tabletops and surfaces (ITS'12) (Cambridge, USA 2012).

[6] MSE-API. https://github.com/ase-lab/MSEAPI

# Peripheral Interaction in Two Metaphor-based Communication Tools

**Yichen Dang**
University of Toronto
Technologies for Aging Gracefully
Lab (TAGlab)
Dept. of Computer Science
40 St. George St. #7224
Toronto, ON M5S 2E4 Canada
yichen@taglab.ca

**Ronald M. Baecker**
University of Toronto
Technologies for Aging Gracefully
Lab (TAGlab)
Dept. of Computer Science
40 St. George St. #7228
Toronto, ON M5S 2E4 Canada
ron@taglab.ca



## Abstract
InTouch is novel communications technology based on metaphors such as picture frames and televisions (plus their remote controls). The goal is to enable isolated individuals, especially frail older adults, to more closely connect with remote family members, without requiring them to master a computer.

## Author Keywords
Assistive technologies, inclusive design, multimedia.

## ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces – Evaluation/methodology; graphical user interfaces, prototyping, user centered design.

## Introduction
"Peripheral Interaction …describe[s] interfaces located on the side of the user's visual field … to describe brief actions performed in parallel to other activities… or to encompass both background perception and interaction…" [1, p. 2], contrasted to … interfaces where "… we … have to focus our attention on each digital device we interact with." [1, p. 1]

Our work is directed at enabling individuals in social isolation, often senior citizens, to be in better touch with family and friends. For most computer-literate


**Figure 1. Transparent interactive function overlay on top of relative's photo (picture frame metaphor)**


**Figure 3. Tablet shown message history from relatives (picture frame metaphor)**

users, this currently happens with email and desktop videoconferencing, and is done by positioning oneself in front of a computer, mobile phone, or tablet, focusing one's attention on an interface, and typing or speaking a message. For many seniors, or individuals with disabilities, or people in unnatural environments such as hospital rooms, this may be difficult.

Our approach is to use communication devices located throughout a natural home environment. This paper reviews the difference between our approach and that of others, and describes two ways in which we are approaching the problem — digital communicating picture frames and interactive flat screen television with augmented remote controls.

## Background

Canadians are aging. In 2011, 5 million Canadians were seniors, a number that may double in the next 25 years to reach 10.4 million by 2036 [2]. Social isolation is a prevalent problem. Current estimates of the prevalence of social isolation in community-dwelling older adults are as high as 43%, ranging from 10 to 43%. [3,4]. Social isolation leads to negative effects on seniors' health, e.g., greater incidence of loneliness, depression, stress, higher blood pressure, etc. [5,6].

This project targets individuals in isolation, especially seniors, who are not interested in or have problems with learning or using technology. We seek to support close connections between such individuals and possibly distant family members, so as to reduce isolation, loneliness, and depression. We employ metaphors of communication devices that appear not to be computers, and thereby seem less threatening.

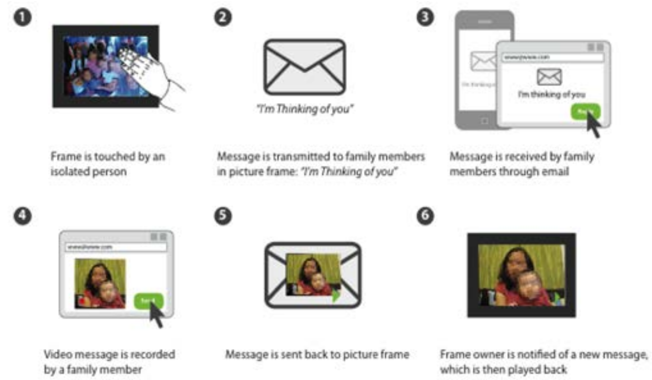


**Figure 2. Workflow of In Touch wave (picture frame metaphor)**

## Differences from existing Family Communications Technology

InTouch differs from most other family communication technologies [7] in that it focuses on asynchronous messaging rather than synchronous video chat (e.g., Skype and Hangouts). It differs from most commercial products for seniors' internet use in that it is just for communications; it does not support search or gaming, nor is it a social media platform for communications with anyone. Because of limited functionality and elegant design, the result is extreme simplicity and ease of learning and use. This is appropriate for frail seniors who do not want to be burdened by complexity. They want to stay in touch mainly with family; the unpredictability in their schedules and health makes messaging more appropriate as a starting point for communication than chat. Our goal is building appliances, most like the approach articulated in [8].

## InTouch

InTouch currently uses two primary interaction metaphors, a picture frame metaphor, and a TV and remote control metaphor.

The picture frame version was implemented as a tablet-based digital communicating picture frame application. The user can choose an action from four function buttons (Figure 1): send a wave as an "I'm thinking of you" message to a family member (Figure 2); record an audio message to send to the family member; take and send a still picture; and take and send a video message. The frame can also receive and display text, photographic, audio, or video messages from family members (Figure 3).

The TV with remote control version consists of an app running on a mobile phone, which displays a traditional TV remote user interface (Figure 4), and an app running on a smart TV, which displays a digital family album on the TV screen (Figure 5). A user can employ the directional pad (shown in Figure 4) to navigate and select a relative. The selected picture is then enlarged to occupy the entire screen and the interaction functions are displayed (Figure 6). Similar to the picture frame version, the TV with remote control version also allows users to record a voice message, capture a video or photo, or send a wave (like the Poke feature in Facebook) to their loved ones.  Once a user selects one function button (e.g., record a video), the remote control app on the mobile device will automatically open the phone's built-in camera and switch to the video capture view, and the smart TV app will allow displays a prompt to ask user to record a video using the remote control app. Once a video is captured, it will be sent to the corresponded relative, and both the mobile control app and the smart TV app will change back to display their regular screens (Figure 4, 6). Our next step with this TV version is to incorporate the message view feature so that users can review message history from their loved ones on the TV screen.

## Going Beyond Current Metaphors and Using Peripheral Interaction

Although we started by designing communication tools that mimic real world objects, we go beyond the capability and properties of the objects themselves. By allowing users to view their loved ones, a regular picture frame provides only one-way communication. In contrast, we offer users a more pleasant interaction experience that supports two-way communication by incorporating a camera and microphone to allow users to send multimedia messages. Moreover, the message history feature can capture and help remind users their unforgettable moments.

The TV version of InTouch breaks the conventional use of a TV, which is for viewing television programs, as well as the conventional concept of a remote, which provides basic functions such as changing between channels or adjusting the volume. The TV version of InTouch allows users to view their relatives' photos from a digital family album on the TV screen. The smart remote not only supports basic functions as does a traditional remote, but also allows users to navigate between relatives in the family album, take photos, record a video/audio message, and send those messages to their loved ones.

InTouch can easily be extended to enable peripheral interaction. For example, in a smart home, when a new message from a loved one arrives, the picture frame version of InTouch can play notification sounds in


**Figure 4. Remote control interface (TV metaphor)**

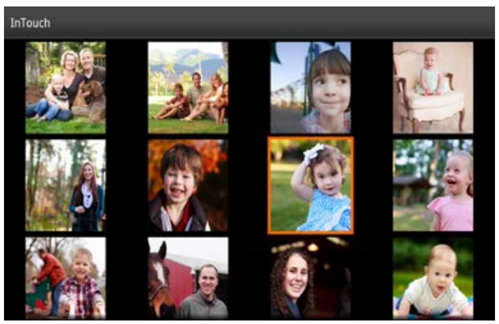


**Figure 5. Family album TV screen (TV metaphor)**

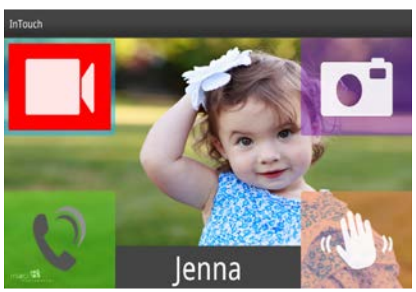


**Figure 6. Transparent interactive function overlay on top of relative's photo (TV metaphor)**

different volumes based on the user's current location; the TV version of InTouch can turn on the TV screen in various ways to display notifications.

We also plan to explore other metaphors that rely on real world objects that people are familiar with, such as those that hold special meaning (e.g., family albums, lockets) or those that we use or see everyday (e.g., watch, fridge magnets), as well as supporting peripheral interaction with those metaphors.

## Conclusions

We have presented the InTouch project, exploring two ways of exploiting existing technology through the use of metaphors to facilitate individuals in social isolation, especially senior citizens, to be in better touch with family and friends. We believe that our tool can provide a less obtrusive and more natural and accessible communication experience, especially as it begins to exploit peripheral interaction.

## Acknowledgements

We are especially indebted to Steve Tsourounis, Anselina Chia, Ian Stewart-Binks, Marc Fiume, and Garry Beirne for the current version of InTouch; Kate Sellen, Spencer Beacock, Sarah Crosskey, and Chris Arnold for user studies; Revera Inc. for enabling us to work with residents of their retirement homes and long-term care facilities; and NSERC, GRAND, Revera, Google, OCE, and CC for financial support.

## References

[1] Hausen, D., Bakker, S., Hoven, E. van den, Butz, A. and Eggen, B. (2013). Peripheral interaction: Embedding HCI in Everyday Life. In proceedings of Interact'13, LNCS 8120, 2 September 2013

[2] Statistics Canada. Estimates of population, by age group and sex for July 1, Canada, provinces and territories, annual (CANSIM Table 051-0001). Ottawa: Statistics Canada, 2011.

[3] Nicholson, N., Molony, S., Fennie, K., Shellman, J., & McCorkle, R. (2010). Predictors of social isolation in community living older persons. Unpublished PhD, Yale University, New Haven, CT.

[4] Smith, T. F., & Hirdes, J. P. (2009). Predicting social isolation among geriatric psychiatry patients. International Psychogeriatrics, 21, 50–59.

[5] Anderson, D. N. (2001). Treating depression in old age: the reasons to be positive. Age & Ageing 30: 13-17.

[6] Cacioppo, J. T., Hawkley, L. C., Crawford, E., Ernst, J. M., Burleson, M. H., Kowalewski, R. B., Malarkey, W. B., Van Cauter, E., & Berntson, G. G. (2002a). Loneliness and health: Potential mechanisms. Psychosomat. Med. 64: 407–417.

[7] Neustaedter C, Harrison S, Sellen A. (Eds.). (2013). Connecting Families. Springer

[8] Mackay, W., Riche, Y., & LaBrune, J. B. (2005). Communication appliances: Shared awareness for intimate social networks. In Position Paper at the CHI'05 Workshop on Awareness Systems

# The Form of Peripheral Interaction – A Framework for Experience Design

**Peripheral Interaction with Desktop Tangibles [2][3]**

**Darren Edge**
Microsoft Research, Beijing, China
darren.edge@microsoft.com

## Abstract
By analysing a set of applications drawn from diverse domains yet all facilitating interaction on the periphery of the user's attention, this paper derives a framework of four qualities that can be used to characterize the desired experience of peripheral interaction in general.

## Author Keywords
Peripheral Interaction; Tangibles; Design Framework

## ACM Classification Keywords
H.5.2 Information interfaces and presentation (e.g., HCI)

## Introduction
In its early stages, the potential of Calm Computing, which "engages both the center and the periphery of our attention" and "moves back and forth between the two" [11], was realized in the form of ambient information displays. Exploiting the opportunity to not just sense but to act on the periphery of our attention, my PhD dissertation explored what I called *peripheral interaction*: "any kind of interaction with objects – physical or digital – that do not occupy the typical centre of the user's attention" [2](p.20).



Since my focus was on tangible interaction for desk-based office work (see sidebar, this page), I also offered an expanded characterisation of the qualities of peripheral interaction in this context:

> *"Peripheral interaction is about episodic engagement with tangibles, in which users perform fast, frequent interactions with physical objects on the periphery of their workspace, to create, inspect and update digital information which otherwise resides on the periphery of their attention."* [2](p.20)

In additional descriptions, I emphasized the "digital, cognitive, and social use" of peripheral interaction with tangibles [2](p.22), especially for activities that are "auxiliary" to the focal work activity [2](p.21). I later clarified these statements as relating to *peripheral tangible interaction* [3], a proper and distinct subset of the more general category of peripheral interaction.

Bakker [1] has done much to populate this broader category, especially with regard to the attentional and cross-modal nature of the periphery. In this paper, I revisit my earlier definitions in light of this and my own subsequent work, expanding them into an experience-oriented design framework. This framework, in contrast with the taxonomic dimensions by Hausen [6], offers four qualities that can characterize the experience of a system designed for peripheral interaction.

**Example Use: FireFlies**

As an example application of the framework, consider the FireFlies system (Bakker [1]) for primary school classrooms.

**Feeling of interaction**

Light-objects displayed in front of each child support *economy of orientation* for the teacher through peripheral awareness of the light colour distribution.

The teacher-tool allows the teacher to set the colour of a child's light-object by first selecting the colour and then the child's name. Combining these two steps would improve the *economy of action*, as was suggested [1](p.137).

Clipping the teacher-tool to the teacher's clothing (e.g., belt) reduced the feeling of encumberment compared with a wrist-worn device (e.g., the prior NoteLet prototype) [1](p.122), increasing tool availability and the resulting *economy of transition*.

*(Continued on next page)*

## The FORM framework

My definitions of peripheral tangible interaction (PTI) can be unpacked into four parts:

1. **Feeling**. PTI can engender a feeling of economy through "fast, frequent interactions", but how else might such feelings arise?
2. **Organization**. PTI can facilitate "auxiliary work activities" embedded in the focal activity, but how else might activities be organized?
3. **Rhythm**. PTI can follow a pattern of "episodic engagement", but how might different episodes of interaction be connected over time?
4. **Meaning**. PTI can consist of "digital, cognitive, and social use" of tangibles, but how might other media be used in such meaningful ways?

*The Feeling of Peripheral Interaction*

Peripheral interaction can lead to feelings of economy compared with achieving the same goals though sequential actions that need complete attentional focus. Three major sources of interaction economy include:

ECONOMY OF ORIENTATION

Peripheral interaction systems can help users to orient their attention towards potential interaction goals. In my desktop PTI system [2][3], tokens provide passive physical reminders of tasks to do, documents to work on, and people to follow. In my subsequent work on mobile micro-learning, flashcard applications provide active orientation towards items to be reviewed at opportune moments (based on location for MicroMandarin [5] and forgetting for MemReflex [4]). The common benefit is the reduced need to remember.

ECONOMY OF ACTION

Peripheral interactions can be crafted to achieve multiple goals at once. In my desktop PTI system [2][3], nudging a token in a particular direction simultaneously selects both a digital object and the attribute assigned to that direction. In my work on presentation tools, SidePoint [11] analyses slide text and offers related "knowledge snippets" in a side panel, allowing peripheral monitoring of potentially useful information while authoring slides. The advantage in both cases is the reduced number of actions required.

ECONOMY OF TRANSITION

Peripheral interaction can help to parallelize multiple activities. In my desktop PTI system [2][3], these are focal and "auxiliary" aspects of the same work activity, performed in adjacent physical spaces at the desktop. In my work on exertion gaming [7][8], virtual spaces connecting physically distant exercise sites support fast switching of attention between exertion, game, and social goals. Such reconfiguration of the environment can reduce the cost of activity transitions.

*The Organization of Peripheral Interaction*

Peripheral interaction can itself be configured in multiple ways with respect to the overlap between the focal and peripheral activities. All help to reduce the risk of the peripheral activity from becoming neglected or forgotten. Prominent organizational forms include:

EMBEDDED ACTIVITY

My desktop PTI system [2][3] embeds auxiliary work activities in the context and flow of focal work activities performed on a desktop workstation. This organization has the benefit that auxiliary tasks created through the focal activity can be acted upon immediately.

**Organization of interaction**

As an open-ended technology for primary school teaching, FireFlies can be seen as potentially facilitating multiple organizations of activity.

It can support the *embedded activity* of communicating with children about their current work [1](p.129), as well as the *background activity* of staying aware of children independent of their work [1](p.131). Another possible use could be to develop background games based around children's vigilance to the teacher changing their light colour, creating a *coupled activity*.

**Rhythm of interaction**

The rhythm of interaction with FireFlies might vary over different scales of interaction.

At a high level, interaction might be seen to follow *regular intervals* throughout the day. At the intermediate level of lessons, interactions might follow *contracting intervals* as the teacher checks the general progress made in the lesson.

*(Continued on next page)*

BACKGROUND ACTIVITY

In my flashcard applications for mobile micro-learning [4][5], the goal is to encourage learners to "identify and exploit the many moments during the day where other distractions are temporarily halted and attention can be diverted" to learning [5] or other activities, e.g., updating social network status [9]. In all cases, the persistent potential for background interaction could encourage more frequent and habitual interactions.

COUPLED ACTIVITY

Exertion gaming [7][8] involves the creation of game mechanics and interaction devices in ways that couple physical exertion and social interaction, even when players are geographically separated (e.g., [8]). This organization allows peripheral engagement with one or more sub-activities (e.g., exertion, social interaction) while focusing on another (e.g., winning the game), all in the context of a fundamentally new, hybrid activity. The benefit is that several independently focal activities can be combined into a single schedulable session.

*The Rhythm of Peripheral Interaction*

While the granularity of episodes of peripheral interaction has already been suggested as a design dimension [6], peripheral interactions addressing the same goal (e.g., to complete a particular task [2][3] or learn a particular word [4][5]) can themselves follow different rhythms that shape the overall experience:

REGULAR INTERVALS

Peripheral interactions for social purposes (e.g., following the availability of a colleague through their contact token [2][3] or playing exertion games with distant friends [7][8]) typically follow a regular pattern with the goal of maintaining social relationships.

CONTRACTING INTERVALS

Peripheral interaction with work items often increases in frequency as deadlines approach, resulting in contracting intervals between item interactions. An example from my desktop PTI system [2][3] is using a task token to track time spent on a task and estimate the time remaining. An example from my PitchPerfect tool for presentation rehearsal [10] is the anticipated increase in rehearsal frequency as the talk approaches.

EXPANDING INTERVALS

Intervals between peripheral interactions can also expand over time as the purpose of those interactions is fulfilled. An example from my desktop PTI system [2][3] is using a document token to interact frequently with a document as it is being created, but then with reduced frequency as the document stabilises over time. Another example from my spaced-repetition flashcard applications [4][5] is that each test of an item strengthens memory for that item, meaning that the intervals between successive tests can be increased.

*The Meaning of Peripheral Interaction*

Peripheral interaction can be meaningful in ways that are instrumental, cognitive, and social, cutting across different input and output media and modalities:

DIGITAL CONTROL

A main purpose of peripheral interaction is to access or update digital state, e.g., work information through subtle physical actions on augmented tokens [2][3], game state through exertion with the physical body [7][8], or the state of learning systems through regular mobile and desktop interaction [4][5][10].

At a low level, interaction between the teacher and any particular child may well follow *expanding intervals* as the child first indicates that they are stuck and the teacher then helps them to overcome sticking points until they make a breakthrough.

**Meaning of interaction**

Although it uses digital technology, FireFlies does not offer *digital control* over any persistent digital state. Future designs with fixed colour meanings could benefit from tracking and analytics over time. This would trade-off against the free use and open interpretation of colours, however, which can currently be used to create ad-hoc *memory cues*, e.g., about which children have yet to be visited in person. The primary use of FireFlies is for *social communication*, and the redundant representation of the distribution of light colours through a soundscape highlights the potential for peripheral interaction to cross the boundaries of any one medium or sensory modality.

MEMORY CUE

Peripheral interaction can support the creation and use of memory cues. Digital cues, e.g., from adaptive flashcards, can prompt both visually [5] and aurally [4]. Physical cues, e.g., PTI tokens [2][3], can prompt passively through their arrangement and annotation.

SOCIAL COMMUNICATION

Peripheral interaction can also support various forms of lightweight social communication. This can be mediated physically, e.g., through the exchange of tokens representing certain rights and responsibilities [2][3], as well as digitally, e.g., through virtual spaces [7][8].

## Using the framework

As with many design frameworks, the FORM framework can be used in multiple ways. Firstly, it can *establish aspirations* for designers thinking about the desired experience of interactions prior to more concrete design work. Secondly, it can *systematize analysis* of a design and its peripheral interaction qualities, encouraging broad consideration of fundamental concerns. Thirdly, it can help *standardize language* for designers talking and writing about their systems, their design choices, and the inherent trade-offs among them.

## Conclusion

Through analysis of both my early definitions of peripheral interaction with tangibles and the peripheral interaction qualities of my non-tangible systems, I have presented a highly provisional framework for the design of peripheral interaction in general. When designing a system for such peripheral interaction, this framework can help designers to map out the qualities of the desired experience and ultimately shape the final form of the system and its broader interaction design.

## References


[1] Bakker, S. (2013). Design for Peripheral Interaction. Eindhoven University of Technology Doctoral Dissertation

[2] Edge, D. (2008). Tangible User Interfaces for Peripheral Interaction. University of Cambridge Computer Laboratory Technical Report

[3] Edge, D. & Blackwell, A. (2009). Peripheral Tangible Interaction by Analytic Design. TEI'09

[4] Edge, D., Fitchett, S., Whitney, M. & Landay, J. (2012). MemReflex: Adaptive Flashcards for Mobile Microlearning. MobileHCI'12

[5] Edge, D., Searle, E., Chiu, K., Zhao, J. & Landay, J. (2011). MicroMandarin: Mobile Language Learning in Context. CHI'11

[6] Hausen, D. (2012). Peripheral interaction: facilitating interaction with secondary tasks. TEI'12

[7] Mueller, F., Edge, D., Vetere, F., Gibbs, M., Agamanolis, S., Bongers, B. & Sheridan, J. (2011). Designing Sports: A Framework for Exertion Games. CHI'11

[8] Mueller, F., Vetere, F., Gibbs, M., Edge, D., Agamanolis, S. & Sheridan, J. (2010). Jogging over a Distance between Europe and Australia. UIST'10

[9] Olivera, F., García-Herranz, M., Haya, P.A. & Llinás, P. (2011). Do Not Disturb: Physical Interfaces for Parallel Peripheral Interactions. INTERACT'11

[10] Trinh, H., Yatani, K. & Edge, D. (2014). PitchPerfect: Integrated Rehearsal Environment for Structured Presentation Preparation. CHI'14

[11] Liu, Y., Edge, D. & Yatani, K. (2013). SidePoint: A Peripheral Knowledge Panel for Presentation Slide Authoring. CHI'13

[12] Weiser, M. & Brown, J.S. (1995). Designing calm technology. Xerox PARC

# Designing Wearable Light Displays for Users and Observers

**Jutta Fortmann**
University of Oldenburg
Germany
jutta.fortmann@uni-oldenburg.de

**Heiko Müller**
OFFIS - Institute for Information Technology
Oldenburg, Germany
heiko.mueller@offis.de

**Wilko Heuten**
OFFIS - Institute for Information Technology
Oldenburg, Germany
heuten@offis.de

**Susanne Boll**
University of Oldenburg
Germany
susanne.boll@uni-oldenburg.de


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## Abstract

Peripheral displays, such as ambient light displays, have a pervasive character and thus are often integrated into everyday items, such as lamps, or into wearables such as jewellery, or clothes. Although many displays are designed to present information that is meant solely for the user, the information display can also be perceived by people in proximity. Because of that a user's willingness to wear resp. use a peripheral display often depends on the reactions of observers, we argue that we need to consider both the user and observers when designing peripheral displays. We close this paper with a number of research questions in the field of wearable light displays that need to be investigated.

## Author Keywords

Peripheral Display, Wearable, Light, Ambient, Social Acceptability

## ACM Classification Keywords

H.5.m [Information interfaces and presentation]: Miscellaneous.

## Motivation and Background

Thinking of peripheral interaction, interaction with wearable devices comes to mind. Interfaces worn on the user's body give excellent opportunities for interacting in a more or less natural way and for displaying information to the user regardless of where she might be at the moment. Typically, wearable displays are designed to present personal information to a user.

As the displays are worn in daily life, they are often not only perceived by the user, but by people in proximity. Especially when a wearable display presents information visually using ambient light, its visibility to observers is even higher. This visibility plays a big role for the social acceptability of a wearable display.

Previous work has shown that the usage and acceptance of wearable technologies is highly influenced by its perceived level of social acceptability [7, 6, 9]. In our view, to design a socially acceptable wearable display means to take three areas into account:

**Privacy concerns of the information's addressee** Who should not see or not be able to decode the to-be-displayed information?

**Self-Presentation of the user** How does the display have to behave and look to make the user feel comfortable?

**Perception of the display by observers** How does the display have to look and present information to be accepted by observers?

If we have a look at previous work on wearable light displays, we see that the information's addressee is often not the only person who can perceive the information. Therefore, we argue that we have to consider both, the user and the observers in the design of such displays. In the following, we list examples in which the user is the only addressee, but different persons can perceive the display of the information.

**Solely user perceives display**
: eye-q [3], AmbiGlasses (with shaded frame) [8]

**User and others perceive display**
: Reminder Bracelet [4], Damage [11], hello [1], ActivMON [2], Pediluma [6]

Especially wrist-worn displays, such as LED bracelets [4, 11, 1, 2] are semi-public displays that - although the information is personal - can be perceived by observers. Pediluma [6] is an ambient light fixed on the user's shoe which visualises the user's physical activity and is highly visible by people in proximity.

Profita et al. investigated how observers perceive the interaction with a body-worn e-textile interface. They found that the perception of controller placement and gesture interaction varied depending on the gender of the user. Besides, they found differences in the perceived importance of aesthetics and usability between US American and South Korean observers [9].

Rico et al. looked at the social acceptability of mobile phone gestures from the perspective of a user. In an on-the-street user study they found that location and audience had an impact on a user's willingness to perform gestures [10].

## Research Questions

As we particularly research wearable light displays, we focus this field in the following research questions.

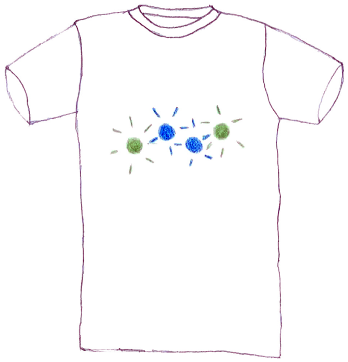

**Figure 1:** Plain t-shirt with single LEDs

**Figure 2:** Brightly patterned t-shirt with LED spots discreetly integrated into the t-shirt design

**1. How do users and observers perceive different body locations for wearable light displays, and in how far do they accept them?**
Suitable body locations have been investigated from a user's perspective for visual displays in general [5]. The social acceptability of different body locations for wearable displays has not been researched yet. Besides, peripheral displays, such as wearable light displays, are perceived differently than conventional displays due to their pervasive character. We need to answer the question how different body locations for wearable, peripheral displays are perceived and accepted by users and observers. Furthermore, when we investigate body locations, we have to explore in how far the possibility to remove a display changes its perception. E.g. on the wrist, a light display could be integrated into a bracelet, but also into the sleeve of a shirt. The nature of a bracelet to be removable or concealable in contrast to that of a shirt which cannot be removed without the user undressing might lead to a very different perception.

**2. In how far does the fact that a display is recognizable as a display affect its acceptance by users and observers?**
In contrast to conventional displays, peripheral displays typically have a pervasive character and can be integrated into everyday items, jewellery, or clothes. A wearable light display could e.g. be presented as single LED spots on a plain t-shirt (see sketch in Figure 1), or it could be concealed as being composed of single LED spots placed onto a brightly patterned t-shirt (see sketch in Figure 2). In the latter example, the single LED spots would hardly be identifiable. The perception and acceptance of these two different light displays might probably be totally different. Therefore, we need to investigate in how far the fact that a display is recognizable as a display or not affects its acceptance by users and observers.

**3. Where should input methods for wearable displays be located and how should they be designed?**
A wearable light display might need input methods to be controlled. We need to explore where these input methods should be located and how these input methods should be designed. E.g. the input could be done directly on the display, on another part of the user's body, or on another mobile device. Also here, the perception of users and observers has to be explored, as specific gestures performed on the body might be perceived differently from a observer's perspective than from a user's.

## Summary
Peripheral displays in general, and wearable light displays in particular are often designed in a way that not only the user as the addressee can perceive the display of information, but also people in his or her proximity. Besides privacy issues, this fact plays a big role with regard to the social acceptability of the display. A user's willingness to wear resp. use a display, especially in public, often depends on the reactions and acceptance of observers. We argue that to design a socially accepted peripheral display, we have to consider both the user and observers in the design process. We formulate a number of research questions in the field of wearable light displays that need to be investigated.

## References

[1] Ahde, P., and Mikkonen, J. Hello: bracelets communicating nearby presence of friends. In *Proc. of PDC '08*, Indiana University (2008), 324–325.

[2] Burns, P., Lueg, C., and Berkovsky, S. Activmon: Encouraging physical activity through ambient social

awareness. In *Proc. of CHI EA '12* (2012), 2363–2368.

[3] Costanza, E., Inverso, S. A., Pavlov, E., Allen, R., and Maes, P. Eye-q: Eyeglass peripheral display for subtle intimate notifications. In *Proc. of MobileHCI '06* (2006), 211–218.

[4] Hansson, R., and Ljungstrand, P. The reminder bracelet: subtle notification cues for mobile devices. In *Proc. of CHI EA '00*, ACM (2000), 323–324.

[5] Harrison, C., Lim, B. Y., Shick, A., and Hudson, S. E. Where to locate wearable displays? reaction time performance of visual alerts from tip to toe. In *Proc. of CHI '09*, ACM (2009), 941–944.

[6] Lim, B. Y., Shick, A., Harrison, C., and Hudson, S. E. Pediluma: Motivating physical activity through contextual information and social influence. In *Proc. of TEI '11* (2010), 173–180.

[7] McAtamney, G., and Parker, C. An examination of the effects of a wearable display on informal face-to-face communication. In *Proc. of CHI '06* (2006), 45–54.

[8] Poppinga, B., Henze, N., Fortmann, J., Heuten, W., and Boll, S. Ambiglasses-information in the periphery of the visual field. In *Proc. of Mensch & Computer '12* (2012), 153–162.

[9] Profita, H. P., Clawson, J., Gilliland, S., Zeagler, C., Starner, T., Budd, J., and Do, E. Y.-L. Don't mind me touching my wrist: A case study of interacting with on-body technology in public. In *Proc. of ISWC '13* (2013), 89–96.

[10] Rico, J., and Brewster, S. Usable gestures for mobile interfaces: Evaluating social acceptability. In *Proc. of CHI '10* (2010), 887–896.

[11] Williams, A., Farnham, S., and Counts, S. Exploring wearable ambient displays for social awareness. In *Proc. of CHI EA '06*, ACM (2006), 1529–1534.

# Evaluating Peripheral Interactions

**Wendy Ju**
Center for Design Research,
Stanford University
424 Panama Mall, Building 560
Stanford CA 94306 USA
wendyju@stanford.edu

## Abstract
One of the key challenges in the design of peripheral interactions is discerning whether the intended interaction will work as intended: Does it accomplish its functional goals? Does it do so appropriately? Does it have more or less attentional cost than desired? Because the interactions in question are non-focal, it can be difficult to ask users about their design directly, or to employ standard UI or UX evaluation techniques. This paper expands on the unique factors involved in evaluating peripheral interactions and outlines some novel techniques that my colleagues and I have developed to accomplish this task.

## Author Keywords
Peripheral interactions; implicit interactions; video prototyping; field studies; evaluation techniques

## Introduction
As computational and electronic components grow smaller and less expensive, and as the reach of networked technologies grows ever more ubiquitous, we find ourselves interacting with computers and interactive devise in ever more contexts and scenarios. While these technologies can help to provide information, assistance and support in a wide variety of applications, they also introduce novel challenges for design. The assumptions, principles and techniques developed for people working desktop computers at work, or playing their living room game consoles at home need to be modified to account for the fact that nowadays people are often interacting with computers and interactive devices in non-focal ways; often the interaction is to-the-side of a person's central focus of attention, and it would be unsustainable to have every device demand attentional focus to function.

One of the keys to design is the iterative design cycle. This cycle has been modeled by numerous design theorists in different ways (e.g. Express-Test-Cycle, [1] Analysis-Synthesis [2] divergence-convergence [3] Designers of novel interactions need evaluation tools and techniques to assess and characterize the how people respond to different designed interactions. Designers of peripheral interactions have all the challenges associated with evaluating interaction designs: that people have to evaluate a pattern of behavior rather than a static dimension, that the interaction often needs to take place in a particular context, that there is a chicken-and-egg problem with the interaction to be designed and the technology needed to support that interaction. In addition, they have to contend with the fact that users often, by

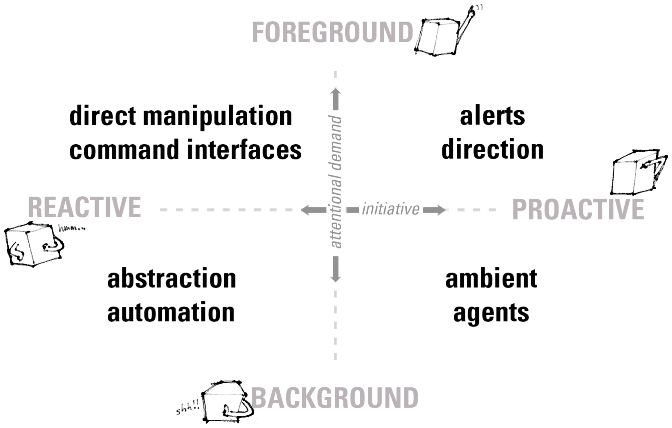


Figure 1. The Implicit Interaction Framework characterizes interactions by their attentional demand and their initiative.

design, do not notice the interaction that is to be evaluated, and often interact with peripheral interfaces tacitly, almost subliminally, so that they themselves are not sure exactly what should occur, only whether things feel more right or more wrong.

## Point-of-View

I personally have been engaged for many years on the design of implicit interactions, which use physical movement and other implicit means of signaling in the pattern of dynamic and responsive behavior between two or more entities. For my research, I have proposed a framework that divides the interaction space by attentional demand (from foreground to background) and by initiative (from proactive to responsive), and I have shown through design examples and controlled studies how successful implicit interactions move through the space of the framework over the course of an interactive exchange. [4].

The Implicit Interaction Framework builds on Bill Buxton's concept of attentional ground [5]: "What we mean by Foreground are activities which are in the fore of human consciousness—intentional activities. Speaking on the telephone, or typing into a computer are just two examples." Buxton's definition of foreground overlaps only with the left half of the implicit interaction framework; he only considers the realm of user-initiated interactions—typing into a keyboard, or switching on a light. Hence, this definition conflates attention with intention, making it inadequate for describing device-initiated interactions—a cell phone ringing, or an automatic door opening. These interactions clearly take place in the foreground but are not at all intentional on the part of the user. As we move into the realm of computational devices, where often it is the device that is leading the interaction, the importance of initiative in determining the right path through the attentional space becomes more obvious and critical.

From the perspective of my work, peripheral interactions are those that take place in large part in the attentional periphery—as opposed in the attentional focus. However, by my framework, and that of Buxton's, peripheral interactions must at some point cross into the attentional foreground, even if just for a few seconds, even if the interactions are non-verbal or non-graphical. My own research argues that the locus-of-agency for these transitions, when interactions move from the attentional background to the attentional foreground and vice-versa, is an important factor. In my framing, peripheral interactions are *communications* with a sender and receiver, and the dynamic of who sends what message when is critical to the nature of the unfolding interaction.

## Special Characteristics of Peripheral Interactions

From the perspective of evaluation, peripheral interactions are distinct from focal interactions in some key ways:

1) By definition, in a peripheral interaction the recipient's attention is shared with at least one other task.

Peripheral interactions take place in a context where multiple things are happening; any evaluation might need to invoke or take place in that context, and with the other tasks at play.

2) Even if the recipient has attention to spare, the peripheral interaction may be beneath attention.

Key aspects of peripheral interactions might evade notice; musicians in a quartet might be focused on starting at the same time and not notice the way that the deep preparatory inhalation or the speed of the lead violinist's bow cues that timing.

3) The sender's role in the peripheral interaction is sometimes subtle or even unconscious.

Beyond not requiring attention, it may even be that the person employing a peripheral interaction gets tripped up or confused if they try to focus on the peripheral interactions they employ, much as people have difficulty tying knots if you ask them questions about how they do it.

4) The rules of how a peripheral interaction should unfold are usually tacit.

We all know how to, say, use our body to shrug "I'm sorry" when we come into a classroom late and try to work our way into an empty seat in the middle of the auditorium—but it would be difficult to articulate what to do or how to recognize this behavior to another person or system.

5) Peripheral interactions are often highly contextual and even culturally specific.

Although there are generalizable patterns in the way that peripheral interactions transition through the attentional and initiative space, the specific gestures or cues often rely upon the interactants ability to decipher deictic references to the objects, affordances and activities involved.

### Some Evaluation Approaches

Here are evaluation approaches that my research colleagues and I have used as ways to understand how people employ peripheral interactions, or to evaluate what factors matter in making for good or bad peripheral interactions. We often use a mix of these approaches simultaneously as the situation demands.

*Field Studies*

Because we are often looking for people's naturalistic response to an interaction, in terms of timing and attention, we often employ field studies of peripheral interactions in quasi-public spaces. This helps fix the context of the interaction, and helps to establish ecological validity for the interaction.

*Wizard of Oz*

To understand the factors that matter for a design, it is often better to fake the interaction than to build a system that really works. This approach always raises objections from engineers, who feel that it is important for realism's sake to use a real system. However, in terms of exploring interaction, a faked system is more flexible, and allows the designers to explore a wider design space than any existing system, which necessarily has trade offs and compromises built into its design. From the interaction perspective, the only thing that matters is that the interaction feels real enough to the user that they can behave or respond naturally.

*Video Prototypes*
Video prototypes allow designers and researchers to capture important situational or scenario-based aspects of interaction, which can be particularly important to peripheral interactions. By staging the context the interactions are designed for, we can better determine if the designed interaction is situationally appropriate. In addition, a video prototype can show a first- or third-person view of the interaction; for instance, we can film the video as if the viewer were interacting with a device, or if they were watching someone else do it. One important aspect of creating video prototypes for evaluation is that the videos be natural enough not to be "selling" the interaction to the viewer. In fact, it is best if the viewer can see several videos of alternative interactions to compare and contrast rather than just having one to evaluate.

*Crowdsourcing*
It can also be useful to use the fact that everyday people have basic intuitions about how to manage the timing of interactions and the right degree of attention to demand. By designing systems that make it easy for people to puppet or wizard of oz novel systems, we can learn important design principles or patterns.

## Mini Case Study

It can be useful to understand how these different types of evaluation can be used throughout the design and evaluation of a peripherally interactive system, and so we would like to highlight a study we made of gesturing automatic doors. [6]

To understand the effect that gesturing doors might have on people's perceptions of and behaviors around gesturing automatic doors, we needed people to be encountering the doors as they would "in the wild" as they were on their way from one place to another. In this study, 1) we first experimented with people's responses using Wizard of Oz gesturing of the doors using a hidden human operator and a lever to push open the door, 2) we had others puppet the doors and talk through their theories of what the doors should do with us, 3) we ran field studies with several different gesturing conditions and then chased down people to have them answer a questionnaire after the fact, and 4) we ran online within-subjects studies using crowdsourced respondants to evaluate video prototypes of a person interacting with a gesturing door.

References


[1] McKim, R. H. (1972). *Experiences in visual thinking* (Vol. 21, No. 1). Los Angeles: Brooks/Cole Publishing Company.

[2] Lawson, B. (2006). *How designers think: the design process demystified*. Routledge.

[3] Pahl, G., & Beitz, W. (1984). *Engineering design* (Vol. 984). K. Wallace (Ed.). London: Design Council.

[4] Ju, W, & Leifer, L. "The Design of Implicit Interactions: Making Interactive Systems Less Obnoxious." Design Issues: Special Issue on Design Research in Interaction Design, 24(3) Summer 2008.

[5] William Buxton, "Integrating the Periphery and Context: A New Model of Telematics," *Proceedings of Graphics Interface* (1995): 239–46

[6] Ju, W., Takayama, L. "Approachability: How People Interpret Automatic Door Movement as Gesture," in IJ of Design Special Issue on Design & Emotion, Vol. 3(2) August 2009.

# Filtered Reality – Keeping Your Peripheral Vision Clean

**Markus Löchtefeld**
German Research Center for Artificial Intelligence (DFKI)
Saarbrücken, Germany
markus.loechtefeld@dfki.de

**Sven Gehring**
German Research Center for Artificial Intelligence (DFKI)
Saarbrücken, Germany
sven.gehring@dfki.de

**Denise Paradowski**
German Research Center for Artificial Intelligence (DFKI)
Saarbrücken, Germany
denise.paradowski@dfki.de

**Antonio Krüger**
German Research Center for Artificial Intelligence (DFKI)
Saarbrücken, Germany
krueger@dfki.de


*Workshop on Peripheral Interaction: Shaping the Research and Design Space at CHI 2014*

## Abstract
The main purpose of the recently advancing Augmented Reality glasses is the augmentation of the physical world with additional information. In this paper we introduce the concept of *Filtered Reality* for Augmented Reality glasses. Instead of adding digital information to the real world, we envision Filtered Reality to use digital information to remove parts of the reality out of the field of view of the user. Similar to the functionality of horse blinders, Filtered Reality allows the user to stay focused on specific tasks or to leverage his mind from the appearance of certain real world objects.

## Introduction
Most parts of the human retina are used for peripheral vision. It lets us detect changes that are happening around our foveal vision [6]. In HCI it has been extensively used in different projects [3,4,5,8]. Today's operating systems make use of the peripheral vision as well. For example OSX shows notifications in a corner of the screen, which normally lies in the peripheral part of our field of view for a sufficiently large screen. Even though these notifications are very small, they are still visible and may lead to distraction from the users original task [7]. This behavior is an evolutionary survival instinct that allowed primal humans to detect menaces approaching them and allowed them to escape or defend themselves against it [6].

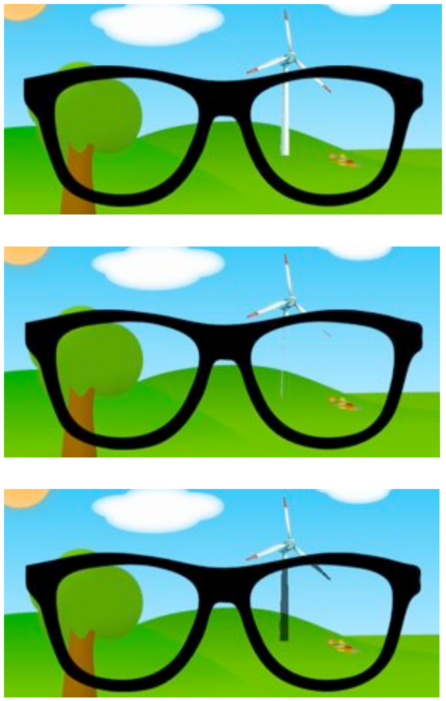

Figure 1: Filtered Reality in *ambient mode*. Top: Unfiltered view with unwanted elements Middle: Background filtered view where the unwanted element is filtered out with background knowledge Bottom: Black-out view where the unwanted elements are grayed out reminding the user of their existence

For horses, a very similar phenomena can be observed. Their eyes are situated on the side of their head. In nature, this is seen as an indicator that they are normally hunted. Such an arrangement of the eyes leads to extensive peripheral vision, which in case of domesticated horses can lead to problems. When riding a horse, the horse is often supposed to stay focused on instructions or a particular task. This is especially important when riding a horse in public or in the direct proximity of people. Through the extended peripheral vision, the horse is exposed an enormous amount of visual stimuli. These can scare the horse and making it bolt. To prevent this, horses are often wearing blinders, which allow them to remain focused by decreasing their field of view [9].

In this paper we introduce the concept of *Filtered Reality* for Augmented Reality (AR) glasses. The introduced concept origins from the aforementioned horse blinders. In contrast to AR, where the goal is to augment the real world with digital information, we envision *Filtered Reality* to exploit digital information to blind out particular parts of the reality out of the field of view of the user. This will allow the user to stay focused on a particular task or it will remove unwanted distractions or annoyances from the current field of view. Using head mounted displays the reality of the user can be filtered by either (1) overlaying background information in front of distracting objects or by (2) reducing the field of vision of the user to keep him focused. In addition to the concept, we describe possible application scenarios and we further present an initial prototype, implementing the most radical version of filtered reality: blocking the whole field of view.

## Concept

*Idea*

The concept that we introduce in this paper is called *Filtered Reality*. With the recent advantages in head mounted display technology, AR-glasses such as Google Glass will be available to the mass market in the near future. Even though Google Glass is only partially suited for Augmented Reality as it only augments a small part in the upper right corner of a user's current field of view, its current propagation boosts up the development of numerous head mounted displays which are better suited for augmenting the whole field of view of the user. While the main purpose of these devices is to add digital information on top of the users field of view, the concept of Filtered Reality envisions the exact opposite.

By using the digital knowledge about content and preferences of the user, Filtered Reality Glasses would remove information from the reality around the user. We envision two different modes: The first one, called *ambient mode*, filters undesired objects from the user's environment. The second mode, called *focus mode*, filters everything except the one thing the user tries to focus on. To realize these two modes, we can apply two methods for altering the current view: At first, we can simply overlay the unwanted parts of the users field of view with a black layer. Therefore its called the *blackout view*. As a second altering method, called *background-filtered view*, the unwanted parts in the current view can be replaced with information from the background. Naturally it is possible to blend between these two modes or even create settings for specific objects so that both modes could occur at the same time.

Figure 3: Filtered Reality in *focus mode*. Top: Unfiltered view with incoming call and Bottom: Blackout view where the incoming call is hidden.

Figure 3: Sensory Deprivator 5000 [2]

*Ambient Mode*

The *ambient mode* is meant to remove specific content from the environment of the user. With that, it allows the user to change his perception of the environment in a ambient way. The content that is removed are elements that the user doesn't want to have in his mind. If for example the user wants to block out a specific person (e.g. his ex-girlfriend) from his life, every time this person appears in his field of view, it is overlaid. This allows him to roam freely through his environment without wasting cognitive resources or getting emotional over certain elements that he normally would encounter.

The background overlay view is especially suited for the *ambient mode*. Overlaying the unwanted elements with available information about the background that is behind the removed element makes it look more natural and nearly unnoticeable for the user. But since such information will not always be available they either have to be interpolated from the environment around the object or the blackout view can be used.

*Focus Mode*

The *focus mode* is derived from the idea of blinders for horses. We envision this Filtered Reality mode to be employed in use cases and application scenarios in which the users focus should not be disrupted by visual stimuli from the peripheral field of view. But it can also be used to steer the users focus and attention to a specific point in the environment. In this setting especially the peripheral vision of the user should be freed from disruption. When the user tries to focus on a certain task, possible changes in his environment can lead to him wasting his cognitive resources on these changes and with that losing his focus. Therefore the whole view except the parts that are needed for completing the users main task are overlaid with a blackout view. For example if the user is writing something, everything that is unnecessary for this task is blocked. This is depicted in figure 2.

In the 14$^{th}$ episode of the second season of the American TV series "*How I met your Mother*", one of the main characters, Ted Mosby, is wearing a set of glasses that are meant to keep him focused and shut off from external influences. They are called the Sensory Deprivator 5000 and consist of sunglasses that are completely covered with duct tape except for two small holes in the center of each glass [2]. Additionally they have blinders on the side to limit the field of view to an absolute minimum (compare figure 3). This system allows him to stay focus and block out any external influences, in his case getting to know the result of the SuperBowl.

*Initial Prototype*

Our initial prototype represents the most extreme version of Filtered Reality since it is blocking the whole field of view of the user with a Black-out View. Even though this seems not to be useful, there are scenarios where such a device can come in handy. It is following the approach of the Joo Janta 200 Super-Chromatic Peril Sensitive Sunglasses of Zaphood Beeblebrox.They are designed to "h*elp people develop a relaxed attitude to danger. At the first hint of trouble, they turn totally black and thus prevent you from seeing anything that might alarm you"* [1]. When for example one is watching a horror movie and there is a scene that might frighten or disturb one, people tend to close their eyes. With the proposed Filtered Reality glasses this can be done automatically. By incorporating a heart

Figure 4: Our prototype consisting of modified ELSA 3D Relevator glasses. Top: Open shades, the user is anxious Bottom: closed glasses, the user is facing danger more relaxed.

rate monitor that detects the increase of stress and arousal, the glasses can be set to black out the vision and leave the user with only the sound. Thus relaxing his mind by not having to watch a disturbing or frightening scene.

Besides closing both shades with a Black-out View the prototype also allows to close both glasses separately. This could be used when a distraction is appearing in the peripheral view of only one side of the user. For example if the user is writing a text and in his periphery a person is passing by on his right side only the right shade could be closed. To implement this of course such distractions need to be sensed.

Our initial prototype consists of a pair of ELSA 3D Revelator glasses connected to an Arduino Uno (compare figure 4). We use a Polar Wearlink heart rate chest strap that communicates that communicates via Bluetooth. If the heart rate increases by 15% over the resting pulse the blinds are closed. This threshold reflects the increase that we found suitable when watching horror movies to shut the shades. With this setup we can ensure that the user will not see disturbing parts while watching a horror movie.

## Conclusion

To the best of our knowledge the concept of Filtered Reality has not been explored yet. Currently there are no insights in how such a technology can be used to help the user in focusing or to remove information to free cognitive capabilities for other tasks.

*Future Work*

Besides extending our current prototype with a field camera we want to evaluate its effectiveness.

Moreover, once suited AR glasses are available we want to develop a prototype that also allows for ambient mode.

Additionally not only visual changes can lead to such loss of focus, auditory disturbance can have an equally high impact. Therefore a holistic Filtered Reality system should cope these as well, e.g. by incorporating special noise cancelling headphones that would remove certain sounds and frequencies.

## References


[1] Adams, D. "The Restaurant at the End of the Universe", Pan Books, 1980

[2] Bays, C. and Thomas, C. “Monday Night Football” How I met your Mother Season 2 Episode 14, 2007

[3] Edge, D. "Tangible user interfaces for peripheral interaction." University of Cambridge Technical Report UCAM-CL-TR-733 (2008).

[4] Hausen, D., Boring, S., Lueling, C., Rodestock, S. and Butz, A. "StaTube: facilitating state management in instant messaging systems." In Proceedings of TEI '12, ACM

[5] Heun, V., von Kapri, A. and Maes, P. "Perifoveal display: combining foveal and peripheral vision in one visualization." In Proceedings of UbiComp '12, ACM

[6] Hunziger, H.W. 2006. "Im Auge des Lesers" 20-22, Stäubli-Verlag: Zürich.

[7] Iqbal, S.T. and Horvitz, E."Disruption and recovery of computing tasks: field study, analysis, and directions.” In Proceedings of CHI ’07,

[8] Ishii, H., Wisneski, C., Brave, S., Dahley, A., Gorbet, M., Ullmer, B. and Yarin, P. "ambientROOM: integrating ambient media with architectural space" In Proceedings of CHI 98 ACM

[9] Stratton, C. "The International Horseman's Dictionary", Jarrold & Sons Ltd, Norwich

# Automated Driving: Shifting the Primary Task from the Center to the Periphery of Attention

**Sebastian Loehmann**
Human-Computer-Interaction Group
University of Munich (LMU)
Munich, Germany
sebastian.loehmann@ifi.lmu.de

**Doris Hausen**
Human-Computer-Interaction Group
University of Munich (LMU)
Munich, Germany
doris.hausen@ifi.lmu.de



## Abstract
The field of peripheral interaction has gained importance in recent years. Researchers explored how to design systems, which can be used in the center but more importantly also in the periphery of users' attention. After developing and evaluating systems for desktop and teaching environments, it is time to apply these insights to other application areas. With this position paper we try to add peripheral interaction to the discussion on automated driving in the automotive domain.

## Author Keywords
peripheral interaction, automotive, automated driving

## Introduction
Peripheral interaction is built onto the concept of calm technology, describing the interaction with systems that can shift between the center and the periphery of attention [11]. Peripheral interaction focuses on the design of interactions that can take place in the periphery and move to the center of attention whenever it becomes important to a user [1]. By now it has mainly been explored and evaluated for computer tasks in the desktop environment [3][4] and during classes in schools [1].

When driving a car, several activities need to be performed in parallel, demanding a high amount of cognitive resources. They can be defined by three categories [10]. Primary tasks describe everything directly involved in the driving task, such as steering and accelerating. Secondary tasks support driving, including activating the windshield wipers or the headlights. Tertiary task are carried out to control in-vehicle infotainment systems, such as radio or navigation system. Due to safety reasons, the primary driving task should always be in the center of attention. However, secondary and tertiary tasks move into the center of attention for short amounts of time.

In recent years, there was a paradigm change in the automotive domain towards automated driving. By adding different sensors, e.g. for rain or light, secondary tasks can now be covered by the car. By using advanced driver assistance systems (ADAS), the car is also able to automatically keep a certain speed or the distance to a car ahead, taking over parts of the primary task. Moreover, novel input modalities such as speech or freehand gestures allow the driver to perform tertiary tasks non-visually while keeping the driving task in the center of attention. This trend will eventually lead towards fully automated driving [5].

This automation in cars will lead to more cognitive resources available for tertiary tasks. In the automotive community, this raised a discussion on how this trend has an influence on the behavior of the driver concerning safety issues and responsibility in case of an accident.

In this paper we will give examples for this behavior change and how this can lead to activities moving from the center of attention to the periphery and vice versa. Finally, we will highlight how this discussion can potentially benefit from the research in the field of peripheral interaction.

## Cars as we have Known them

When carrying out the primary task of driving a car back in the days, it required most of our attention to fulfill the driving task in a safe manner. We had to watch the traffic around us, use the gas pedal to speed up and hit the break at stop lights or when getting to close to a car in front of us.

Secondary driving tasks such as using the windshield wiper or turning on the headlights did not require visual attention, because controls were placed around the steering wheel and easy to reach and remember. The act of noticing that we actually need to perform the task and the task itself needed little mental resources and moved into the center of our attention for only a short amount of time. Thus, we were able perform these secondary task in our periphery.

Tertiary tasks in general are more complex and require longer execution times as well as focus and attention shifts compared to secondary driving tasks. Therefore, when having a conversation with a co-driver or choosing a destination on our navigation screen, both, primary and tertiary task, move back and forth between the center and the periphery of our attention. This is can lead to dangerous situations: as soon as the driving task is in the periphery for too long, we might leave our lane or overlook a child running after a soccer ball. In cars without any driving assistance, the primary task must be in the focus of our attention at all times.

## Cars as we Know them

Cars today come with a variety of assistant systems. As a result, many secondary tasks do not have to be carried out by the driver and thus can be ignored. A rain sensor triggers the activation of the windshield wiper and adjusts the frequency to the amount of rain. Data from light sensors can be used to adjust the headlights. The resources freed by the car taking over can now be used for the primary task, in the best case.

But also parts of the primary task are taken over by advanced driver assistant systems. Adaptive Cruise Control (ACC) is able to keep a certain speed and a safe distance to the car ahead. When activated, the system takes care of acceleration and breaking. In city traffic, it is able to stop the car behind the one ahead, e.g. at a red light. Besides holding the steering wheel and watching traffic, the driver is relieved from significant parts of the primary task.

Concerning tertiary tasks, automation plays an important role as well. The goal is to reduce the drivers' visual distraction to help them keep their eyes on the road. An example is the integration of the phone into the infotainment system of the car. When receiving a phone call, the radio is automatically muted. Numbers can be dialed using speech input, avoiding visual attention and moving parts of this task to the periphery. Gestural input can also help to perform tertiary tasks in the periphery of attention, like muting the radio in stressful situations [6].

## Cars as we will Know them

When taking a look at research projects and recent concept cars, automation in the automotive context is increasing and will eventually lead to fully automated driving in the future. Google shows how their Self-Driving Car [7] is able to reach destinations without needing the driver to steer or to use the pedals. It manages to halt at a stop sign, turn into a parking lot and take a turn at a traffic light without human input. The primary task of driving, or at least large parts of it, can in theory move to the periphery of attention.

On the other hand, infotainment systems will be more mature, increasing the amount of available information and the ability to entertain the car's passengers. Tesla offers a large touch screen in their Model S [9], enabling drivers to stream music, surf the Internet or read emails. They can find the nearest charging or fuel station or simply explore the area on digital maps.

## Primary Tasks in the Periphery of Attention

When combining the automation of the primary and secondary driving tasks with the rich availability of infotainment systems in the car, we can conclude that seemingly clear assumptions of what should be in the focus and what in the periphery of attention become questionable. Tertiary tasks start to move into the center of attention more often [5], as a significant amount of cognitive resources will be no longer claimed by the primary task. Studies on driving behavior in fully-automated cars [5][8] show benefits for driver safety but ironically also hint to the increased distraction from the primary task and thus to improper and therefore dangerous behavior in critical driving situations.

We argue that research on peripheral interaction, with its goal to design for interactions that can shift between the center and the periphery of attention, can benefit the discussion on automated driving.

Following problems need to be addressed:

1. The definitions of primary, secondary and tertiary tasks in the car need to be linked to the definition of peripheral interaction.
2. Studies on the change of driving behavior in fully-automated cars need to be interpreted with the research done in the area of peripheral interaction in mind.
3. Further investigations on which tasks move when into the center or the periphery of attention during automated driving are needed.
4. Next to the ongoing development of non-distracting infotainment systems, it will be essential to focus on how to successfully shift the driving task back to the center of attention in critical situations.

## Conclusion

In this paper, we tried to show links between research done in the fields of peripheral interaction and behavioral change due to automated driving. Assistant systems gradually take over primary and secondary driving tasks and thereby free cognitive resources for the driver to concentrate on tertiary infotainment tasks. A close look on attention shifts away from and especially to the driving task in critical situations will be necessary. This discussion in the automotive domain can benefit from theoretical models and study results of peripheral interaction research.

## References


[1] Bakker, S., van den Hoven, E. and Eggen, B. FireFlies: Physical Peripheral Interaction Design for the Everyday Routine of Primary School Teachers. In *Proc. of TEI2013*, ACM, 2013, 57–64.

[2] Bakker, S. Design for Peripheral Interaction. PhD thesis, TU Eindhoven, Netherlands, 2013.

[3] Hausen, D., Boring, S., Lueling, C., Rodestock, S. and Butz, A. StaTube: Facilitating State Management in Instant Messaging Systems. In *Proc. of TEI2012*, ACM, 2012, 283–290.

[4] Hausen, D., Richter, H., Hemme, A. and Butz, A. Comparing Input Modalities for Peripheral Interaction: A Case Study on Peripheral Music Control. In *Proc. of INTERACT 2013*, Springer, 2013, 162–179.

[5] Jamson, H., Merat, N., Carsten, O. and Lai, F. Fully-Automated Driving: The Road to Future Vehicles. In *Proc. of Sixth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design.* (2011).

[6] Loehmann, S., Knobel, M., Lamara, M. and Butz, A. Culturally Independent Gestures for In-Car Interactions. In *Proc. of INTERACT 2013*, Springer, 2013, 538-545.

[7] Self-Driving Car Test: Steve Mahan. http://www.google.com/about/jobs/lifeatgoogle/self-driving-car-test-steve-mahan.html (Last accessed January 7th 2014)

[8] Stanton, N. A., Young, M. S., Walker, G. H., Turner, H. and Randle, S. Automating the driver's control tasks. *International Journal of Cognitive Ergonomics 5*, 3 (2001), 221-236.

[9] Tesla Model S. Features & Specs: Interior http://www.teslamotors.com/models/features#/interior (Last accessed January 7th 2014)

[10] Tönnis, M., Broy, V. and Klinker, G. A survey of challenges related to the design of 3d user interfaces for car drivers. In *Proc. of 3DUI 2006*, IEEE, 2006, 127-134.

[11] Weiser, M. and Brown, J. S. Designing Calm Technology. PowerGrid Journal, 1996.

# Peripheral Microinteraction For Wearable Computing

**Denys J.C. Matthies**
HCI Lab
National University of Singapore
15, Computing Drive
Singapore, 117417
matthies@nus.edu.sg

**Eric Lecolinet**
Télécom ParisTech – LTCI CNRS
UMR 5141
46, rue Barrault
75013, Paris, France
eric.lecolinet@telecom-paristech.fr

**Simon T. Perrault**
HCI Lab
National University of Singapore
15, Computing Drive
Singapore, 117417
simon.perrault@nus.edu.sg

**Shengdong Zhao**
HCI Lab
National University of Singapore
15, Computing Drive
Singapore, 117417
zhaosd@comp.nus.edu.sg



## Abstract
Computers are ubiquitous and the trend of wearable devices is continuously increasing. Nowadays these small devices are permanently supplying the user with many pieces of information. Accessing and responding to this information without involving the user's full attention is the goal of peripheral interaction, hence allowing the user to execute her main task with minimum interruption. In this paper, we introduce the concept of peripheral microinteraction, and highlight and illustrate properties allowing users to seamlessly interact with their devices with a minimal visual, cognitive, and physical cost in mobility context. We also present interaction concepts showing the feasibility of peripheral microinteraction.

## Author Keywords
Peripheral interaction; microinteraction; eyes-free interaction; wearable computing; input interfaces.

## ACM Classification Keywords
H5.2 [Information interfaces and presentation]: User Interfaces – Interaction Styles.

**Figure 1.** InEar BioFeedController illustration.

**Figure 2.** ShoeSoleSense prototype.

## Introduction

Designing mobile interactions with computing devices is facing a new opportunity with the recent development of wearable computers that can be directly worn on the user's body. As such, computing devices can be always accessible [2] and visible [5] for their users. This enables new interaction scenarios that were less explored in the past. However, it remains unclear on how to best design interactions with such devices.

As users often need to pay attention to mobility tasks, suitable interactions in mobile scenarios should be performed quickly and easily without requiring the user to concentrate on the interaction itself, as pointed out by Ashbrook through the concept of microinteraction [1]. Such interactions include responding to an incoming phone call, switching music, taking a picture, responding to a notification, making a short note, etc. While microinteractions have been explored for mobile devices, they have been less explored for peripheral wearable devices, which motivates our work.

## Peripheral Microinteraction in Mobility

We aim to combine the properties of both peripheral interaction and microinteraction as "peripheral microinteraction". In this study, we define peripheral microinteraction as a kind of interaction that takes place whenever a user wants to change the state of a computational system while being focused on a primary task. Changing the song on a music player while crossing the street is an example of such an interaction. To qualify it as a peripheral interaction, the user must not have to switch his attention from his primary task to the interaction with the device itself. Efficient multi-tasking is an obvious expected advantage. A distraction of a primary task may possibly cause danger – as in the given scenario, crossing the street without paying enough attention to the road could lead to an accidental event. Peripheral interaction is thus desirable in mobile situations. We aim to propose how to design simple and suitable interaction technique for peripheral interaction to accomplish safe interactions in such scenarios.

## Properties of Peripheral Microinteraction

The most common alternative input modalities in research seem to be audio and gestural input. Voice-based input, while becoming more available with systems such as Siri, seems to be often rapidly neglected by users (85% of people haven't used Siri since iOS 7 was released[1]). This might be due to the fact that voice based input techniques are still not as reliable as expected by the users - especially in noisy environments. Also, social awkwardness of such techniques can still be a problem. This leads us to extract the two most important properties, **reliability** and **social acceptance,** which may even prevent users from interacting with wearable devices at all. Factors that influence the frequency of use are the **availability** of a device (e.g. a smartphone buried deep inside a bag or clothes) and the **joy of use**. Moreover, interactions tend to fail or to be disliked when inputs are too complex. Because the complexity of the output of a microinteraction is generally small (e.g. vibrating a phone), its corresponding input should be accordingly simple. Thus the **simplicity** of input (e.g. simple and memorable gestures) also has a positive impact. In the context of mobility, when being on the go or driving a

[1] http://www.ibtimes.com/apple-ios-7-85-percent-people-havent-used-siri-46-percent-think-apple-oversold-its-release-1437900 [Last retrieved 2nd January 2014]

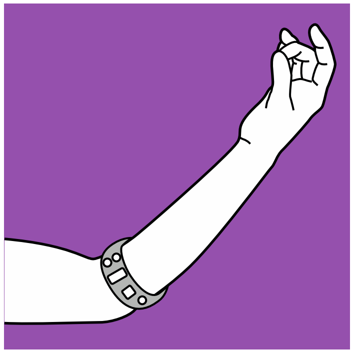

**Figure 3.** Augmented armband example.

**Figure 4.** The Ring Ring concept.

car, it is desirable to enable the user to have a free field-of-view. This kind of interaction is called **eyes-free**. However, in mobile contexts, when driving a car, carrying groceries or wearing gloves, using hands to interact with the system is not always possible. Hence, **hands-free** interaction is also an desirable aspect for microinteraction in mobility.

## Advantageous Concepts for Peripheral Microinteractions in Mobility

We now describe concepts that introduce different approaches regarding input and output which rely on different hand, foot or head gestures.

*InEar BioFeedController*

"InEar BioFeedController" [7] (**Figure 1**) is a headset that enables fully hands-free and eyes-free interaction with mobile devices. Simple head gestures (exaggerated head shaking & nodding) and facial expressions (eye winking or ear wiggling) enable a response on incoming phone calls or a control of a music player without distracting the user from his primary task (e.g. having a walk). The prototype is safe for use in traffic, because no tactile or visual contact is required, thus visual attention can remain on the road.

*ShoeSoleSense*

"ShoeSoleSense" [8] (**Figure 2**) is an insole that enables location independent hands-free and eyes-free interactions through the feet. The prototype measures pressure under the feet and enables a device such as a smartphone to exploit an additional input modality through foot gestures (e.g. through different ways of tapping on the ground). Also it is possible to use peripheral information, taking into account whether the user is walking, standing or lying/sitting to adjust the output. For example, while walking, phone calls might be ringing louder. Also, the prototype provides additional feedback by heating up the feet and vibrating in dedicated areas on the surface of the insole. So events such as incoming phone calls can also be felt through vibrations under the feet and the level of priority can be transmitted by the temperature..

*Arm/Wrist-band*

Utilizing an armband (**Figure 3**) as an input device is an interesting approach which has been considered by several researchers. (e.g. using EMG: Saponas et al.[10], using an accelerometer: Feldman [4]). Combining both sensor types enables precise arm and hand gestures. For instance finger snapping can serve to trigger an action such as starting an audio recording, shaking arm to decline an incoming phone call, etc.

*Ring Ring*

The "Ring Ring" [6] (**Figure 4**) takes advantage of the light emitted by LEDs to provide non intrusive information. By varying the light intensity and color, it is possible to easily transmit useful information. We evaluated the prototype in a context where users were focused on a primary task. One result is that participants could not distinguish different light intensities emitted by the ring efficiently when focusing on a primary task, showing that visual perception in peripheral interaction is significantly reduced.

*WatchIt*

"WatchIt" [9] (**Figure 5**) is a wristband augmented with position sensors that allows users to interact eyes-free. Through simple pointing or sliding gestures with the finger along one dimension, "WatchIt" provides an efficient mean to perform reliable peripheral

**Figure 5.** WatchIt enables eyes-free interaction on wristband.

**Figure 6.** earPod prototype.

interactions that require no visual attention and only need reduced cognitive attention as shown by a user study. Performing gestures on the wristband while being in a conversation is nearly imperceptible and does not lead to interruptions or awkward situations.

*earPod*

"earPod" [11] (**Figure 6**) is an eyes-free menu technique using touch input and reactive auditory feedback. earPod allows simple tapping and sliding gestures to select a variety of commands. Study results indicate that earPod is potentially a reasonable eyes-free menu technique for general use, and is a particularly well suited for mobile device interfaces.

## Conclusion

In this paper, we highlighted properties that should enable beneficial peripheral microinteraction in mobile contexts: reliability, social acceptance, simplicity, eyes-free and hands-free interaction. In order to be performed eyes-free and with a minimal cognitive attention, interaction techniques can rely on proprioception as users know the exact location and orientation of their body parts. Gestural interaction with wrist, arm, feet, head movements often already enable hands-free and peripheral interaction, so that the user can pursue his primary task, which is generally executed using the hands and the fingers. Additionally, the output channel can be enriched by leveraging on the various human senses  for instance by feeling temperature or pressure, by distinguishing between melodies or tone frequencies or by perceiving color changes in the peripheral field of view. We hope these properties and concepts will help in designing new techniques for peripheral microinteraction in mobility context.

## References


[1] Ashbrook, D. Enabling mobile microinteractions. PhD Thesis, Georgia Institute of Technology (2009).

[2] Ashbrook, D. L., Clawson, J. R., Lyons, K., Starner, T. E. and Patel, N. Quickdraw: the impact of mobility and on-body placement on device access time. In *Proc CHI '08*. ACM, 219-222.

[3] Drouin, M., Kaiser, D. H., Miller, D. A. Phantom vibrations among undergraduates: Prevalence and associated psychological characteristics, *Computers in Human Behavior*, 28(4), July 2012, 1490-1496.

[4] Feldman, A., Tapia, E. M., Sadi, S., Maes, P. and Schmandt, C. ReachMedia: On-the- move interaction with everyday objects. In *Proc ISWC'05*. IEEE, 52-59.

[5] Harrison, C., Lim, B. Y., Shick, A. and Hudson, S. E. Where to locate wearable displays?: reaction time performance of visual alerts from tip to toe. In *CHI '09*.

[6] Sun, L., Perrault, S. T. and Lecolinet, E. Getting Users' Attention using LEDs. *Technical report*, 2014. *http://hal.archives-ouvertes.fr/hal-00945792/*

[7] Matthies, D. J. C. InEar BioFeedController: a headset for hands-free and eyes-free interaction with mobile devices. In *CHI EA '13*. ACM, 1293-1298.

[8] Matthies, D. J. C., Müller, F., Anthes, C. and Kranzlmüller, D. ShoeSoleSense: proof of concept for a wearable foot interface for virtual and real environments. In *Proc VRST '13*. ACM, 93-96.

[9] Perrault, S. T., Lecolinet, E., Eagan, J. and Guiard, Y. Watchit: simple gestures and eyes-free interaction for wristwatches and bracelets. In *Proc CHI '13*. 1-10.

[10] Saponas, T. S., Tan, D. S., Morris, D., Balakrishnan, R., Turner, J. and Landay, J. A. Enabling always-available input with muscle-computer interfaces. In *Proc. UIST'09*. ACM, 167-176.

[11] Zhao, S., Dragicevic, P., Chignell, M., Balakrishnan, R. and Baudisch, P. earPod: eyes-free menu selection using touch input and reactive audio feedback. In *Proc CHI '07*. ACM, 1395-1404.

# Supporting Notifications and User Guidance through Subtle Cues

**Bastian Pfleging**
VIS
University of Stuttgart
Pfaffenwaldring 5a
70569 Stuttgart, Germany
bastian.pfleging@vis.uni-stuttgart.de

**Niels Henze**
VIS
University of Stuttgart
Pfaffenwaldring 5a
70569 Stuttgart, Germany
niels.henze@vis.uni-stuttgart.de

**Albrecht Schmidt**
VIS
University of Stuttgart
Pfaffenwaldring 5a
70569 Stuttgart, Germany
albrecht.schmidt@vis.uni-stuttgart.de



## Abstract
In this paper, we present our idea of supporting user guidance (e.g., for unfamiliar user interfaces) and user notification (e.g., informing about incoming messages or an upcoming appointment) using subtle information cues. The idea is to provide usable hints to users without actively distracting them. While various subtle information concepts like subliminal communication and subtle gaze direction have already been studied, previous research partly reports conflicting results about the effectiveness of such systems or is limited to certain application domains. Therefore, we aim at exploring and extending the design space between subliminal, subtle / ambient, and clearly visible cues and want to investigate how such cues can be integrated into everyday user interfaces to form a type of peripheral communication.

## Author Keywords
Peripheral information cues; subliminal interaction; desktop notifications

## ACM Classification Keywords
H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces.

## Introduction and Concept

When using traditional computers or mobile devices, users often experience situations where they execute a certain task such as writing a text document or e-mail but are distracted by notifications of other applications running in the background (messaging, etc.).

*User Notification*

Most applications provide more or less visible notifications that visualize for instance if a new message arrives or that the next meeting begins soon. Oftentimes, these notifications distract the user from the original task which is currently solved in a different application: The user pays attention to the notification and switches to the initiating application. Thus, the initial task is interrupted and needs to be continued later even if the remaining time to do so was only a few seconds. In these cases, the remaining task completion time will often increase as the user needs additional time to get back into the initial task context and resume this task [5]. As mentioned by Iqbal et al. [5] one idea is to defer such notification to "best" moments.

While a method to defer notifications requires a workload-aligned task model, our approach is instead to look for methods that are less distracting than current, obvious notifications. The idea is to make the user aware of a certain notification (content or type of message / notification) without distracting from the current task. As a consequence, the users might be able to decide on their own when to react to a certain notification instead of doing so immediately due to the 'annoying pop-up'. As an example, we imagine a subtle visualization method that can be used to notify the user about an upcoming calendar event. Our hope is that this information can then subconsciously be processed so that the user will be able to leave the office at the right time without having noticed a real notification. An initial sketch of the concept is shown in Figure 1. By using the notification method as described before we hope that such notifications become *peripheral* such that the user can actually receive and understand the content of a message while doing a different task.

*User Guidance*

A second use case is related to the guidance of novice users: When a user interacts with an interfaces of a certain complexity that s/he is rather unfamiliar with, task completion time is often longer than for expert users. In such situation, different options to guide a user are possible, such as instructions, dialog boxes, online help [9], or customized views that contain less information. However, these approaches can annoy the user, either due to their distraction potential or simply because they transmit the feeling of being a novice user. Therefore, our goal is to employ a less obvious technology such as subtle cues that still guide the user (e.g., directing the user's gaze), but without causing him or her feeling distracted. The idea is that this makes the user feel empowered and at the same time less distracted. The concept of subconsciously directing the user's gaze could also be integrated in situations where applications today offer a visible hint to the user. This idea could not only help to distract the user less than current methods, but also to save screen space, which is still important, e.g., when using mobile devices. For instance this could be used to remind the user about a mandatory field that still needs to be filled or to not forget to attach the document just mentioned in the email. In this case, the user's gaze should be attracted to the corresponding elements of the UI (i.e., the form field or the attachment button) so that s/he remembers to start the interaction.

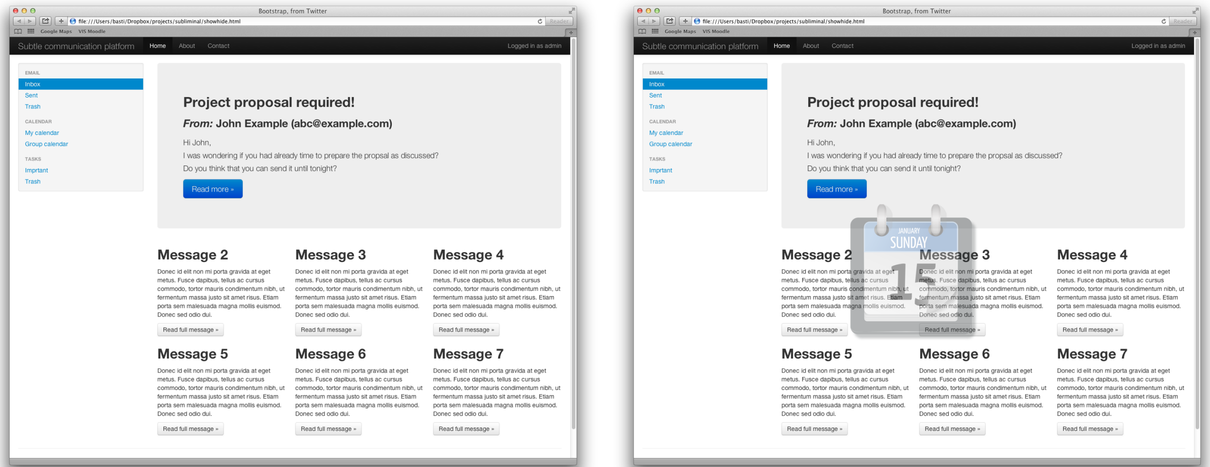


**Figure 1:** Example of an e-mail interface with subtle notifications. On the left, the normal interface is shown. The right illustration shows an (exaggerated) example on how to notify the user about an event that is about to start. The idea is that in a real interface this message is almost unperceivable to not distract the user (e.g., by using a much lower opacity). To explore the design space of subtle notifications, we aim at testing different methods to show such notifications, e.g., regarding repetitions, masking and fading mechanisms, and visibility durations.

In order to achieve the concepts of user guidance and user notification, we explore the space of notifications and cues between visible, ambient, subtle, and subliminal display methods. The idea is to find suitable visualization and notification concepts that do not distract but at the same time allow to notify or guide the user.

## Technology and Visualization

As our concept should be applicable to many different applications and situations, the aim is to develop a framework that allows existing applications to extend their capabilities through such subtle notifications. Therefore, we first of all need to find a suitable notification method.

The following section considers potentially interesting technologies that have already been investigated and how they could be applied to our concept.

The least noticeable method is probably the idea of subliminal information communication. Previous work in this domain looked successfully for instance at providing textual help to users [4, 10] or to support learning solution strategies [3]. In contrast, other projects could not prove an effect of subliminal interfaces [2]. As at least some concepts seemed to be successful, it will be interesting to see if this method is suitable to notify the user.

For subtle cues, first concepts emerged [1, 6, 7] to use such concepts for specific applications. In these projects, *subtle gaze direction* was employed to direct the user's gaze. However, this technique has only been applied to specific tasks / visualizations and not to ordinary user interfaces. The idea of subtle gaze direction was taken up by Pfleging et al. [8]. They tried to extend the concept to non-blinking cues and apply this to basic shapes as an abstraction of typical user interfaces. However, they could only find an effect for clearly visible cues. Therefore, the investigation of mostly visible cues or advance subtle cues is one idea that could be used in our concept.

## Conclusion

While some concepts for unobtrusive communication and support have already been explored in previous projects, the ideas have not yet been investigated for guidance and notification in ordinary graphical user interfaces. We hope to fill this gap with our research and aim at providing detailed insights in how to allow subtle, unobtrusive user guidance or less distracting notifications.

## References


[1] Bailey, R., McNamara, A., Sudarsanam, N., and Grimm, C. Subtle Gaze Direction. *ACM Trans. Graph. 28*, 4 (Sept. 2009), 100:1–100:14.

[2] Campbell, T. The effect of subliminal learning: Using a direct manipulation computer interface. *UNF Theses and Dissertations* (Jan. 1993).

[3] Chalfoun, P., and Frasson, C. Subliminal Priming Enhances Learning in a Distant Virtual 3D Intelligent Tutoring System. *IEEE MEEM 3* (2008), 125â130.

[4] DeVaul, R. W., Pentland, A. S., and Corey, V. R. The memory glasses: Subliminal vs. overt memory support with imperfect information. ISWC '03 (2003), 146–153.

[5] Iqbal, S. T., and Bailey, B. P. Investigating the effectiveness of mental workload as a predictor of opportune moments for interruption. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '05, ACM (New York, NY, USA, 2005), 1489–1492.

[6] McNamara, A., Bailey, R., and Grimm, C. Improving search task performance using subtle gaze direction. In *In Proc. APGV 2008* (2008), 51â56.

[7] McNamara, A., Bailey, R., and Grimm, C. Search task performance using subtle gaze direction with the presence of distractions. *ACM Trans. Appl. Percept. 6*, 3 (Sept. 2009), Article 17, 1–19.

[8] Pfleging, B., Henze, N., Schmidt, A., Rau, D., and Reitschuster, B. Influence of subliminal cueing on visual search tasks. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '13, ACM (New York, NY, USA, 2013), 1269–1274.

[9] Shneiderman, B., and Plaisant, C. *Designing the User Interface*. Pearson Addison Wesley, USA, 2010.

[10] Wallace, F., Flanery, J., and Knezek, G. A. The Effect of Subliminal HELP Presentations on Learning a Text Editor. *Information Processing & Management 27*, 23 (1991), 211–218.

# Casual Interaction: Scaling Fidelity for Low-Engagement Interactions

**Henning Pohl**
University of Hannover
Hannover, Germany
Henning.Pohl@hci.uni-hannover.de

**Michael Rohs**
University of Hannover
Hannover, Germany
Michael.Rohs@hci.uni-hannover.de

**Roderick Murray-Smith**
University of Glasgow
Glasgow, Scotland
Roderick.Murray-Smith@glasgow.ac.uk



## Abstract
When interacting casually, users relinquish some control over their interaction to gain the freedom to devote their engagement elsewhere. This allows them to still interact even when they are encumbered, distracted, or engaging with others. With their focus on something else, casual interaction will often take place in the periphery—either spatially by, e.g., interacting laterally or with respect to attention, by interacting in the background.

## Author Keywords
Casual interaction; peripheral interaction; engagement

## Introduction
While most systems today assume a user is fully engaging with them, this is often (a) not possible for users due to interaction constraints, or (b) not desired by users because they choose to focus their attention on a different task. In what we call the *focused–casual continuum* [9], users themselves decide how much they engage with a system. This requires interactive systems to offer input over a whole range of user engagement levels, or different devices, custom-built for specific engagement levels.

In this paper, we will outline how casual interactions are related to peripheral interactions. Both focus on interaction where the user is engaged elsewhere, maybe concerned primarily with another task, but still wishes to interact with something else on the side. While similar, we also think there are some differences, which we will also try to carve out.

## Interacting at Varying Levels of Control and Engagement

In Figure 1, we show an example of an interactive system that offers multiple ways to interact, each varying in level of engagement required and level of control available. Here, a user is controlling a moodlight—changing brightness and hue of the emitted light. Choosing a precise RGB color is possible by changing the value of three color sliders using touch in the device. While this enables a user to specify a hue and brightness very accurately, it also requires her to observe the device and execute fine motion as well. The color change could be observed from the light itself, but targeting the touchscreen controls requires a view of the device.

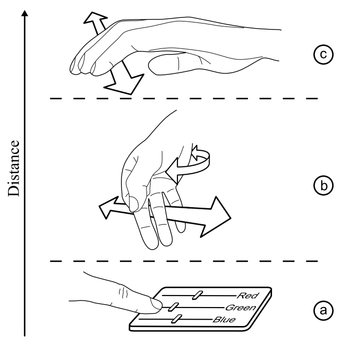


**Figure 1:** In this example, a user can pick the color of a moodlight at varying levels of control. It enables (a) fine control via touch on the device, (b) in-air control of brightness and hue by moving and rotating the hand, and (c) abstract control of mood by waving over the device.

Two different ways to interact are available above the device. In both cases, the user does not need to closely observe the device anymore. Immediately above the device, moving the fingers back and forth can be used to control the brightness of the light, while rotating the hand changes the hue. Here, a comparably high level of control is retained while the demand of engagement with the device is much lower than with precise touch interaction. Finally, a user can just wave the hand above the device, signaling it to change to a different mood setting. No fine color control can be exerted in this case, but at the same time the engagement demand is much lower than in the other cases. Now, a mood change can be made without close interaction with the device—it can happen in the background/periphery of the user.

Note how at all time the user gets to take back control and intervene if more precise command specification is desired. This can be as simple as grabbing the device instead of gesturing above it. By enabling the user to make an active choice of engagement level, the system is relieved from determining that level itself. While some previous work exists (e.g., by Horvitz [7]) that tries to estimate how much control a user requires at a moment, we postulate that a user will always know best how much control she indeed wants. The focused–casual continuum also explicitly allows for more than two levels of control/engagement (other than agents that either take over or not).

## What Motivates Users to Interact more Casually?

We identify three categories of reasons users are prohibited from or unwilling to fully engage with their devices: social, mental, or physical constraints.

*Social Constraints*
Close interaction with a system is not socially acceptable in all situations. Users adapt their behavior to their current surroundings and settings like a family dinner are less appropriate for device use than an evening alone on the couch. Depending on the situation, users might even deliberately show disengagement from their device to project a more attentive self [6].

*Mental Constraints*
When distracted or tired, users are less able to focus on an interaction. Even primary task, are shifting in and out of users' focus [1]. Ultimately, users can only make so many active choices [2] and offering them a way to interact at a lower level of control would already be worthwhile.

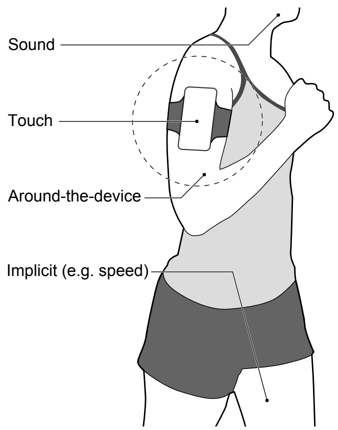


**Figure 2:** Here we show multiple ways a runner could interact with a mobile device. Using touch, precise input can be made, but the runner would need to stop and possibly remove the device from its holder. Around-device interaction is less precise but also could be used while still on the move. Without stopping (but possibly with slowing down), a user could issue voice commands to a device. Finally, the act of running itself could control a system. For example, a music player that picks songs based on the running speed could be implicitly controlled.

*Physical Constraints*
Physical reasons for users being unable to exert full control can be as drastic as missing limbs or as basic as wearing gloves. Systems should not assume that a user at any given moment is able to invest the full range of agility and precision in a task. Think of carrying a number of shopping bags: touch interaction with a phone is harder in those circumstances, but wished for nonetheless.

In all this situations, users are less *able* to interact with their devices yet not necessarily less *desiring* to do so. By allowing them to interact at reduced levels of engagement (and thus control), we can give them a way to retain some control and not give it up completely (e.g., to an agent).

## How Casual Interaction Differs from Peripheral Interaction

An important property of the focused–casual continuum is that it is gradual. While actual implementations might only offer discrete interaction levels, the concept itself allows for a continuously varying level of control. For example, recently we have investigated using pressure to allow users to determine the level of control they desire over their phone's autocorrect functionality [10]. Slight and less precise touch allows for less engaged typing and signals the system to correct most errors, while more deliberate input allows to gain back control and override system corrections. Thus casual interaction can move between happening more in the periphery or the focus of a user's attention—in contrast to peripheral interaction's stress of secondary tasks.

We would also like to stress that casual interaction comes with a strong focus on user choice. Instead of automatically determining how much control a user desires, we believe users themselves should be the ones who pick the level of engagement and control they want. Especially when it comes to reacting socially appropriate, a user is likely to make better choices than an automated system on how much device interaction is acceptable. We believe it is this aspect of user control, that is distinctive of casual interactions. Concepts, such as Buxton's foreground/background model [3], Ju et al.'s implicit interaction framework [8], or Dix's incidental interactions [5] also see this range as a binary choice, in contrast to casual interaction's gradual continuum.

## Device Outlook for Casual Interaction

Small mobile devices inherently require close engagement for most interactions. Especially touch interaction is hard to perform without focusing on the device. We believe that to make good use of the focused–casual continuum, future devices need to be able to sense more around the device. Previously we have explored interaction with a prototype simulating a mobile device able to sense hand movements in the air above the device [9]. With current developments like PrimeSense's *Capri*[1] or Occipital's *Structure Sensor*[2], we believe many mobile devices will soon have the capability to sense the world around them.

Once our devices are able to sense around them, we believe there will be a surge in ad-hoc utilization of everyday objects for interaction purposes (similar to, e.g., [4]). When interaction can be decoupled from our devices, we will be freed from the need to grab them and touch them every time we want to make an input. Instead, we believe there will be an abundance of choices on how to relay commands to, e.g., our phones—some requiring users to closely engage, while others pick up subtle changes to allow for less engaging interactions.

[1] `http://www.primesense.com/solutions/sensor`
[2] `http://structure.io`

## Conclusion

Casual interaction, like peripheral interaction, allows users to control a system with less than full attention/engagement. There are a number of reasons why we think a user might want to relinquish some control in a number of situations. But casual interaction leaves that choice to the users, allowing them to pick the right balance of engagement and control at a given moment themselves. With devices' sensing capability soon enabling them to pick up input not just directly on the device but possibly all around them, the question of how to use this freedom for appropriate interactions will become more pressing. We believe the casual–interaction continuum is one way to capture the range of possible interactions and the motivations for choosing between those more in the foreground and those more in the periphery of a user.

## References


[1] Bakker, S., van den Hoven, E., and Eggen, B. Acting by hand: Informing interaction design for the periphery of people's attention. *Interacting with Computers 24*, 3 (Apr. 2012), 119–130.

[2] Baumeister, R. F., Bratslavsky, E., Muraven, M., and Tice, D. M. Ego Depletion: Is the Active Self a Limited Resource? *Journal of Personality and Social Psychology 74*, 5 (1998), 1252–1265.

[3] Buxton, B. Integrating the Periphery and Context: A New Taxonomy of Telematics. In *Proceedings of Graphics Interface - GI '95* (1995), 239–246.

[4] Cheng, K.-Y., Liang, R.-H., Chen, B.-Y., Laing, R.-H., and Kuo, S.-Y. iCon: Utilizing Everyday Objects as Additional , Auxiliary and Instant Tabletop Controllers. In *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10*, ACM Press (New York, New York, USA, 2010), 1155–1164.

[5] Dix, A. Beyond intention - pushing boundaries with incidental interaction. In *Proceedings of Building Bridges: Interdisciplinary Context-Sensitive Computing* (Glasgow University, 2002), 1–6.

[6] Goffman, E. *The Presentation of Self in Everyday Life*. Anchor, New York, NY, 1959.

[7] Horvitz, E. Principles of Mixed-Initiative User Interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems the CHI is the limit - CHI '99*, no. May, ACM Press (New York, New York, USA, 1999), 159–166.

[8] Ju, W., Lee, B. A., and Klemmer, S. R. Range: Exploring Implicit Interaction through Electronic Whiteboard Design. In *Proceedings of the ACM 2008 conference on Computer supported cooperative work - CSCW '08*, ACM Press (New York, New York, USA, 2008), 17–26.

[9] Pohl, H., and Murray-Smith, R. Focused and casual interactions: Allowing users to vary their level of engagement. In *Proc. CHI '13* (2013).

[10] Weir, D., Pohl, H., Rogers, S., Vertanen, K., and Kristensson, P. O. Uncertain Text Entry on Mobile Devices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '14* (2014).

# Peripheral Interactions with the Interactive Belt-Worn Badge

**Norman Pohl**
University of Stuttgart
Pfaffenwaldring 5a
70569 Stuttgart, Germany
norman.pohl@vis.uni-stuttgart.de



## Abstract
The Interactive Belt-Worn Badge is a system that was designed with the aim to perform light and quick interactions in mind. This position paper will describe interaction concepts feasible with this device and show on the basis of examples how these concepts can be used to allow peripheral interactions.

## Author Keywords
Smart interactive badge; retractable string; interaction techniques

## ACM Classification Keywords
B.4.2 Input/output and data comms: Input/Output devices; H.4.1 Information systems applications: Office Automation; H.5.2. Information interfaces (e.g., HCI): User interfaces.

## General Terms
Human Factors; Design.

## Introduction
In this paper I like to introduce a device which allows peripheral interaction: The Interactive Belt-Worn Badge [1]. This device is basically an augmented version of a traditional identity badge with a retractable string (like those typically worn in offices and labs, etc.). The retractable string of these badges enables to have the


**Figure 2:** A traditional Badge with retractable string (left) and Interactive Belt-Worn Badge with an augmented retractable string and a display in the form factor of traditional badges.

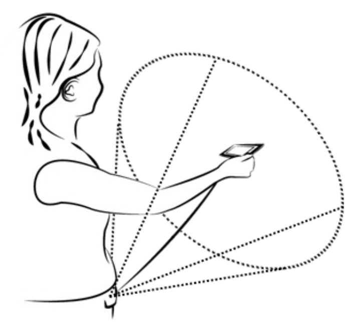

**Figure 1:** Interaction space

badge very quick at hand and allows a fast and almost automatic interaction in common use cases like proofing the identity or opening a door.

By leveraging and augmenting this form factor, the Interactive Belt-Worn Badge can be a device which allows peripheral interaction. To achieve this the retractable string is augmented with a potentiometer and a joystick to enable sensing the distance and the direction in which the string is pulled out. This creates an interaction space directly in front of the user. It is always relative to position of the user and has the shape of a cone (Figure 1). With the sensed information, the device is capable of calculating its position within this cone.

The badge part is augmented with a screen to dynamically display information and a few buttons to interact with its content. (The prototype seen in Figure 2 features more buttons to figure out the best position for the buttons). The main purpose of these buttons would be to select items or abort an action and to provide a clutching mechanism. The clutching mechanism could be used to bring the screen in a comfortable position to read as well as to extend the interaction space. Additionally the badge part could feature a motion processing unit to detect the motion and orientation of the badge as well as a vibration motor and/or a buzzer to alert the user.

## Related Work

The interactive belt-worn badge combines the use of a retractable string for input with the idea of using corporate badges as wearable electronic devices. Both concepts have been explored in previous publications:

*Retractable string input devices*

Rantanen et al. described a smart clothing system for the arctic environment which featured a unit containing a display mounted at a retractable string [2]. The user

**Figure 3:** Spatial positions

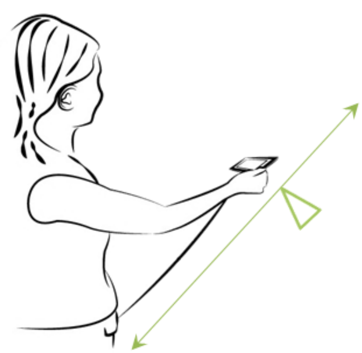

**Figure 4:** 1D slider

could scroll 1D-menus and enter text by pulling the unit to certain distances and squeeze it to make a selection. The DistScroll system [3] enabled similar interactions and investigated potential uses a bit further.

Koch and Witt proposed a system which could measure the extent and direction a string is pulled out [4]. They evaluated it with a user study in which users had to select voxels from a 3x3x3 grid. The results revealed limitations in their hardware but showed that users could be more accurate in making selections by using a retractable string compared to a gamepad.

Blaskó et al. presented and discussed a retractable string built into a watch or other small device with limited display space as an alternative to other physical controls [5]. Additionally they presented the idea of incorporating display pixels within a retracting string.

*Corporate identity badges*
The Active Badge [6] is a system that allows to localize users within a room. Later iterations included a buzzer and LEDs for user feedback and two buttons for input. The subsequently developed Active Bat [7] increased the accuracy by using ultrasonic ranging technology, which allowed the interaction with posters and computer displays situated in the environment.

A wearable badge featuring a display was developed by Falk and Björk. Their BubbleBadge [8] was designed to present visual information to the people around the wearer and as such did not support dynamic interactions. The Uber-Badge [9] is another example of a wearable display badge. It supported peer-to-peer communication, resulting in a dynamic information display.

## Peripheral Interactions

With the interactive belt-worn badge knowing its relative position to the user, one way of interacting with it is to trigger actions or display informations at specific spatial points in the interaction space (which as shown by Koch and Witt is possible quite accurately). For example the wearer might drag the badge out to a position right in front of him to check his emails (Figure 3). He might want to do this because he thinks of an unanswered email and wants to check if his communication partner has already answered that email.

If the wearer drags the badge out to a position a bit more right the badge might display the upcoming appointments together with information like the time and location. In this way the wearer could quickly look up the room number of the next meeting or see if there is enough time to get a coffee before the next appointment.

This kind of interaction may reduce the mental load required to retrieve informations compared to using a smartphone: Users typically need to get smartphones out of a pocket or bag first, following by unlocking them to select the appropriate application to finally retrieve the desired information. With the Interactive Badge no retrieval from a pocket and no unlocking is needed due to the design of the system: The Badge unlocks itself as soon as it's dragged out of its resting position. Also selecting the application should be faster than it is with a smartphone because the interaction space is larger and the positions might be learned into muscle memory over time. This might lead to mental load that is low enough so that such interactions can become peripheral.

Another concept to interact with the Interactive Belt-Worn Badge is to interpret the spatial position directly as input value. For example the volume of a media player on the smartphone could be adjusted according the distance of the string pulled out (Figure 4). The value could be confirmed with a button press on the display part.

The motion processing unit inside the badge part can be used to detect gestures performed by the user. This can be useful in conjunction with the interaction concepts mentioned before: The media player could fast-forward the music if the badge is tilted or skip the entire song if the user shakes the badge. The calendar and email application could flip to the next or previous page if the badge is tilted.

*Ending the interaction*

To end the interaction with the Interactive Belt-Worn Badge the user just needs to let go the display. Due to the retractable string the display is pulled back into its resting position. A smartphone in contrast needs to be locked or turned off and then put back to a bag or pocket.

## Transition to Explicit Interaction

An interesting aspect of the Interactive Belt-Worn Badge is that many of the interactions might be a peripheral interaction in the beginning. They might stay peripheral, but there is also a chance that they lead to an explicit interaction if certain conditions are met. For example when the user checks his emails to see if he got an answer he is waiting for, the interaction might stay peripheral if the answer isn't there yet. He even might not remember the topics of the three most recent emails if asked directly after checking them. But if the user got that eagerly awaited email, he might decide to open it right away to read it, and therefor switch to an explicit interaction with all attention shifted to that interaction.

The same might occur if the user needs more detail for the next appointment in the calendar (i.e. because he completely forgot about it) or if the user wants to select a specific track from playlist of the media player (i.e. because the current tracks don't fit the current mood of the user).

## References


[1] Pohl, N. et al. An interactive belt-worn badge with a retractable string-based input mechanism, Proc. CHI '13, ACM Press, pp. 1465-1468.

[2] Rantanen, J. et al. Smart Clothing for the Arctic Environment, Proc. ISWC 2000, p. 15-24.

[3] Kranz, M. et al. DistScroll - A new One-Handed Interaction Device, Proc. IWSAWC 2005.

[4] Koch, E., Witt, H. Pull'n'Retract: Experimenting with a String-based Wearable Input Device, Pervasive 2008.

[5] Blaskó, G. et al. Prototyping Retractable String-Based Interaction Techniques for Dual-Display Mobile Devices, Proc. CHI '06, ACM Press, pp. 369-372.

[6] Want R. et al. The active badge location system. ACM Trans. Info. Syst. 10, 1 (Jan. 1992), 91–1.

[7] M. Addlesee et al., "Implementing a Sentient Computing System," Computer, vol. 34, no. 8, 2001, pp. 50-56.

[8] Falk, J. and Björk, S. The BubbleBadge: A Wearable Public Display. CHI '99 Posters, pp 381-319.

[9] Laibowitz , M. and Paradiso, J. The Uber-Badge - A Versatile Platform at the Juncture between Wearable and Social Computing, Proc. Pervasive 2004.

# Exploring the Potential of Peripheral Interaction through Smart Furniture

**Kathrin Probst**
Media Interaction Lab
University of Applied Sciences
Upper Austria
kathrin.probst@fh-hagenberg.at

**David Lindlbauer**
Media Interaction Lab
University of Applied Sciences
Upper Austria
david.lindlbauer@fh-hagenberg.at

**Michael Haller**
Media Interaction Lab
University of Applied Sciences
Upper Austria
michael.haller@fh-hagenberg.at

**Bernhard Schwartz**
Medical Technology Department,
University of Applied Sciences
Upper Austria
bernhard.schwartz@fh-linz.at

**Andreas Schrempf**
Medical Technology Department,
University of Applied Sciences
Upper Austria
andreas.schrempf@fh-linz.at



## Abstract
During everyday office work we are used to controlling our computers with keyboard and mouse, whereas the physical space around us remains largely unattended. Addressing this untapped potential, we follow an approach that is based on gestural interaction with smart furniture interfaces, subtly blended into the work environment. Adding to existing work on peripheral interaction, we provide a case study of a novel input technique that turns a flexible chair into a ubiquitous input device within an office environment. We propose using imprecise semaphoric chair gestures to support always-available, hands-free, and eyes-free interaction.

## Author Keywords
Smart Furniture, Chair Interaction, Peripheral Interaction, Office Environments

## ACM Classification Keywords
H.5.2. [Information Interfaces & Presentation]: User Interfaces - Ergonomics

## Introduction
In the course of a working day we perform a variety of different activities, oftentimes in parallel, and keep shifting our attention back and forth between tasks of varying importance and urgency. These shifts might be deliberate actions such as briefly skipping a song when

**Figure 1.** Users controlling a desktop computer through the movements of their body, while sitting on a sensor-equipped flexible office chair.

listening to music while writing a report, or situational context changes such as reacting to an instant messenger notification during the creation of a project schedule. Regardless of the specific use context, such scenarios always involve a focused primary task and a peripheral secondary task requiring temporary attention, only to slide back into the periphery again. Still, such short interruptions can disrupt our concentration, make us lose focus and decrease our performance [1]. This is especially problematic in the office context, where we want our attention focused on the actual work. Thus, it is desirable for transitions between primary and secondary tasks to work rather effortlessly, with minimal physical and mental demand. We think that this type of interaction with secondary tasks should aim at keeping a task in the periphery of our attention, while still providing the opportunity to control it when needed.

In our work, we focus on improving users' interaction with peripheral tasks in the office context by providing the opportunity for gestural interaction with smart furniture (e.g., navigating to the next item in a list by briefly swinging the lower body to the right while sitting on an interactive chair). Thereby, in comparison to traditional input devices, our goal is to reduce physical constraints (i.e., supporting hands-free, eyes-free interaction) and mental effort (i.e., using simple gesture mappings) to support input that can take place nearly in parallel with a user's primary task. We believe that smart furniture is very well-suited for such peripheral interaction styles due to its ubiquity and currently untapped potential as input medium. As an example, we propose the concept of using a flexible, interactive office chair for imprecise gestural interaction within a desktop environment.

## Related Work

With digital information and communication technologies finding their ways into the work environment, people spend increasing time in managing various activities simultaneously, which results in frequent context switches that may have negative effects on performance and emotional well-being [1]. Therefore, efforts have been made to design calm technologies that aim to reduce information overload by letting users select what information is at the center of their attention [11]. Moreover, special interest has been on the design of inattentive interaction techniques that can be easily performed in the periphery of attention. *Whack Gestures* is an example of an inattentive, inexact interaction technique, allowing users to interact without the use of fine motor skills or detailed visual attention [3]. It has been shown that such semaphoric gestures can provide substantial benefits for secondary task interactions [4], and allow users to vary their level of engagement with a task [7].

While early work in the field of smart office environments has demonstrated the ubiquitous integration of interactive technology into the work environment [10], the focus has more recently turned towards supporting users by extending interaction to the periphery. *The Unadorned Desk* is a recent example which exploits the physical space around a desktop computer as input canvas [2]. Similarly, our work adds to the research that has been done in the field by proposing a novel case study that extends the design space of such inattentive interfaces to gestural interaction with smart furniture that is subtly blended into the work environment. Thereby, we make use of novel input approaches, which go beyond touch or freehand gestures to provide key aspects of inattentive, imprecise, eyes-free, and hands-free interaction.

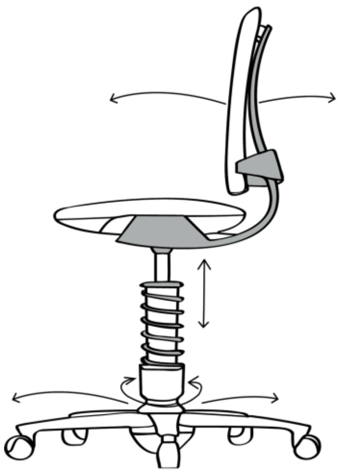

**Figure 2.** Horizontal and vertical degrees of freedom provided by the 3Dee™ flexible chair (www.swopper.de/en/3dee).

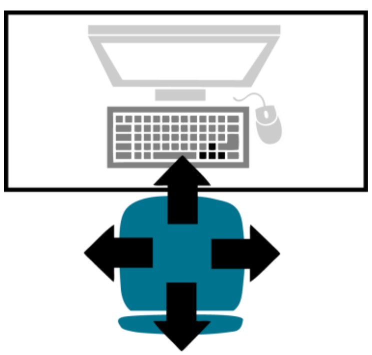

**Figure 3.** Frequently used music player commands are mapped to the four canonical directions.

## Smart Furniture for Peripheral Interaction

Furniture elements can be found everywhere, pervasively embedded into our daily life, barely noticed as functional tools or design elements. Currently, we see more and more devices with embedded sensing and communication capabilities [11]. We believe that furniture provides a particularly interesting design space for fitting interactive technologies in our everyday life, as it is an integral part of our physical environment that can be ubiquitously accessed, and provides familiar simple operations and appealing tangible material properties. If we are thinking of a traditional desk workplace for example: the chair, the table, or the floor itself could serve as alternative input/output channels that broaden the design space for peripheral interaction, making room for other use cases where traditional interaction techniques might not be suitable.

*Chair-Based Peripheral Music Control*

Normally, a chair is just a well-designed and robust device that supports sitting. In the recent years, the design has advanced to increasingly *flexible chairs* that support dynamic sitting. To explore whether this feature could be used to control a computer, we developed an interactive chair interface based on a commercially available office chair (see Figure 2) that we equipped with motion-sensing capabilities [8]. Taking advantage of human capabilities to perform simple motor activities while sitting (e.g., tilting, rotating, bouncing), it supports interaction through a set of semaphoric chair gestures. We implemented two application scenarios that utilize these gestures in the context of focused (i.e., web browsing) and peripheral (i.e., music control) interaction with a desktop computer [9].

In a user study with 15 participants (6 female; 20-51 years), we compared the chair-based input to keyboard and touch interaction in a peripheral music control scenario [9]. Therefore, frequently used music player commands were assigned to the four canonical directions left/right to play the *previous/next track*, and up/down to *increase/decrease volume* (see Figure 3). Corresponding chair gestures were performed through simple tilt movements (i.e., briefly swinging the hips to a specific direction) along the left-right or front-back axis of the chair. Results of the comparison between chair, keyboard, and touch interaction indicate that the novel chair input technique is particularly supportive for peripheral interaction due to the benefits of always-available, eyes-free, hands-free operation. Furthermore, participants enjoyed the possible diversification of interactions, and introduction of light physical activity into the work routine. The embodied aspects of chair-based input seemed to facilitate interaction, and support reduction of resumption lags. Based on these unique features, chair gestures seem highly promising for opportunistic interaction with non-critical peripheral tasks, as they enables users to effortlessly interact with an application and rapidly re-focus on other ongoing activities. Similarly, this approach could be extended to other application scenarios (e.g., e-mail) and gestures (e.g., vertical bounce movement).

## Discussion

We believe that letting users control secondary tasks through their physical work environment has great potential to simplify their interaction with computers. By combining smart furniture interfaces with imprecise gestures (which need to be easy to learn, memorize, and perform), we believe that we can provide interactions that support seamless transitions between tasks.

**A Case Study of Peripheral Interaction through Smart Furniture: Key Benefits of an Interactive Office Chair Interface**

**Always-Available:** while sitting in front of a computer, motion gestures on an interactive chair can potentially be detected anytime to provide always-available access to application functions [4].

**Eyes-Free:** the resulting interactive chair interface can be operated eyes-free, as input is based on body movements that require no attention to a visual interface [6].

**Hands-Free:** with a chair as hands-free input device, users are provided with a true additional input dimension, as their hands can remain on keyboard and mouse, or perform other activities (e.g., writing, handling a phone).

**Engaging:** the introduction of technologies that integrate motor body movements into our interactions with digital systems provides great potential to avoid monotony and physical inactivity [5].

Still, there are open questions and challenges to be addressed. In particular, when augmenting everyday objects with sensing capabilities, gestural interaction can be hard to distinguish from natural movement (e.g., fidgeting, posture changes). Therefore, providing either explicit or implicit mode-switching mechanisms will be essential to avoid false activations. Furthermore, the regular usage of specific furniture items should not be influenced negatively. Especially when designing for gestural interaction within office environments, social acceptability is a further important factor to be taken into account. To resolve possible issues in this context, gestures for interaction with smart furniture items will need to be designed carefully and tested in respect to social, performance-related, and functional factors.

## Outlook

We plan to extend our research by investigating the application of gestural chair input for other usage scenarios beyond the proposed music player control (e.g., notification handling), and exploring new possibilities for smart furniture interaction within a desktop environment (e.g., foot gestures on the floor). Further, we plan to conduct a field study that allows us to generalize our approach and create guidelines on the usage of imprecise gestures with smart furniture, especially for peripheral interaction in the office context.

## Acknowledgements

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## References

[1] Bailey, B., Konstan, J., and Carlis, J. The Effects of Interruptions on Task Performance, Annoyance, and Anxiety in the User Interface. *INTERACT 2000*, 593–601.

[2] Hausen, D., Boring, S., and Greenberg, S. The Unadorned Desk: Exploiting the Physical Space around a Display as an Input Canvas. *INTERACT 2013*, 140–158.

[3] Hudson, S.E., Harrison, C., and Harrison, B. Whack Gestures: Inexact and Inattentive Interaction with Mobile Devices. *TEI 2010*, 109–112.

[4] Karam, M. and schraefel, m.c. A Study on the Use of Semaphoric Gestures to Support Secondary Task Interactions. *CHI EA 2005*, 1961–1964.

[5] Levine, J. a. Non-Exercise Activity Thermogenesis (NEAT). *Best Practice & Research Clinical Endocrinology & Metabolism 16*, 4 (2002), 679–702.

[6] Oakley, I. and Park, J. Designing Eyes-Free Interaction. *HAID 2007*, 121–132.

[7] Pohl, H. and Murray-Smith, R. Focused and Casual Interactions: Allowing Users to Vary Their Level of Engagement. *CHI 2013*, 2223–2232.

[8] Probst, K., Lindlbauer, D., Greindl, P., Trapp, M., Haller, M., Schwartz, B., and Schrempf, A. Rotating, Tilting, Bouncing: Using an Interactive Chair to Promote Activity in Office Environments. *CHI EA 2013*, 79–84.

[9] Probst, K., Lindlbauer, D., Haller, M., Schwartz, B., and Schrempf, A. A Chair as Ubiquitous Input Device: Exploring Semaphoric Chair Gestures for Focused and Peripheral Interaction. *CHI 2014*

[10] Streitz, N., Geißler, J., Holmer, T., Konomi, S., Müller-Tomfelde, C., Reischl, W., Rexroth, P., Seitz, P., and Steinmetz, R. i-LAND: An Interactive Landscape for Creativity and Innovation. *CHI 1999*, 120–127.

[11] Weiser, M. and Brown, J.S. The Coming Age of Calm Technology. In *Beyond Calculation: The Next Fifty Years of Computing*. 1997, 75–85.

# ShoeSoleSense for Peripheral Interaction

**Bernhard Slawik**
Human-Computer-Interaction Group
University of Munich (LMU)
Amalienstr. 17
80333 Munich, Germany
bernhard.slawik@ifi.lmu.de


Workshop on Peripheral Interaction: Shaping the Research and Design Space at CHI 2014

## Abstract
As miniaturization of wearable computers progresses, interacting with those types of personal, always-on systems becomes of ever growing importance. Head-up displays and smart watches are a convenient way of instantaneously informing the user of incoming notifications (like e-mails, phone calls and such), but actively responding to a notification using buttons or speech still leaves a lot of space for improvements.

This paper shows how sensors embedded into the users insoles can be used to capture force distributions and toe gestures to allow for covertly controlling a computer using one's feet and toes; not only in the periphery of the body (the feet), but also in the periphery of attention (hands-free and out of sight).

## Author Keywords
Wearable Computing; Peripheral Interaction; Foot Interaction; Alternative Input Methods

## ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces: Haptic I/O; Input devices and strategies (e.g. mouse, touchscreen)

## Introduction

As wearable computers become more and more ubiquitous, there is also an increasing number of situations where interaction with these devices is not possible due to the hands being occupied by another (main) task and speech input would be considered socially awkward.

Some smart watches allow for limited interaction by flicking the wrist [6], so only the performing hand needs to be free in order to carry out the movement. However, when both hands (or just the performing one) are occupied, even this interaction is not possible any more. Smart rings [2] can still be operated by single fingers, but during a firm grasp even finger movement is not feasible any more. Speech input, as it is used in modern smart phones, is not tied to hand movement, but is limited by background noise and social awkwardness in crowded situations. This raises the need for novel forms of interaction for a wider range of situations, like carrying out a manual task with both hands, while sitting in a crowded train or while studying in a library.

This paper explores the possibility of using the feet and toes to allow interaction in every-day situations. It is part of an ongoing research project that evaluates the use of foot based interaction in different usage scenarios (see also [4]).

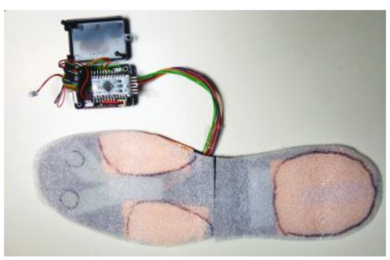


**Figure 1.** Early prototype showing the microcontroller (top) and the foam coated insole (bottom) with 3 copper pads and 2 FSRs

## Related Work

The prototypes used in this work are based on *ShoeSoleSense* [4], where a similar system has been used to navigate virtual reality environments by leaning in the desired direction and therefore re-distributing the weight on the user's feet.

Commercial sensory insole products [1][5][7], which measure forces at the feet, have been announced in the recent past, mainly for sports performance assessment and *quantified self* applications. If these devices can also be used for foot-based interaction, as described here, must be determined once these devices become available.

The use of wearable cameras to capture gestures has been evaluated for increased immersion in games [8], as well as for covertly issuing commands to wearable devices [3] by using a camera mounted on a shoe, pointing up towards the hands. But so far research focused mainly on using the foot as a whole, not the individual toes, to carry out the interaction. By leaving the foot itself at rest, it is expected to allow for covertly controlling a computer system eyes- and hands-free.

## Hardware

The wearable hardware prototype consists of two parts: An insole with sensor pads and a Bluetooth equipped microcontroller that transmits the sensor data to the personal area network (PAN) where it can be analyzed and reacted upon. There are two kinds of force sensors built into the insole, capacitive and resistive ones (see Figure 1).

### *Capacitive Posture Sensors*

The capacitive sensors consist of self-adhering copper pads at the heel part of the insole, as well as the inside and outside ball. The pads are coated with a resilient foam layer that forms an insulation between the copper pad and the foot. When the foot depresses on the foam, the distance between skin and copper decreases slightly, effectively increasing the capacitance of the copper pad. This capacitance can be derived by the

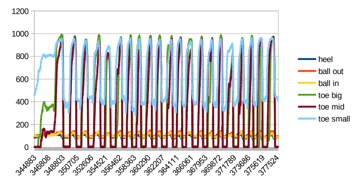



**Figure 2.** Oscillation of raw sensor data while walking (X: controller uptime in microseconds; Y:10 bit readings)

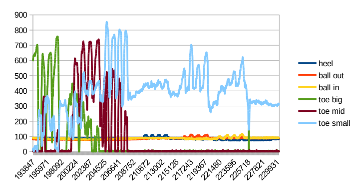



**Figure 3.** Four consecutive spikes in raw data for each of the 6 sensors

microcontroller by sending a pulse of electricity to the pad and measuring the time it takes to charge and to discharge again. Measuring time allows for a higher dynamic range than measuring voltages.

On the other hand, measuring forces in this indirect manner has some caveats: The measured capacitance is also influenced by the type of floor below the shoe, varying skin conductivity and properties of the socks. Furthermore, the prototype has wires running from the pads to the controller. Since these are not well shielded they also act as part of the capacitor and produce noise when touched.

All in all, the capacitive sensors used in this prototype offer highly dynamic data on the user's posture changes, but do not seem suitable as the only source of sensor data for the intended application.

*Resistive Toe Sensors*
In order to also capture movements of the toes, a set of force sensitive resistors (FSRs) are incorporated into the insole. The insulating foam distributes the pressure evenly across the corresponding FSRs' surface area for optimal operation of the sensors.

The FSRs' resistance is a more robust way to measure force, since capacitive effects do not noticeably influence the readings. In contrast to the capacitive sensors, the FSRs are connected to the microcontroller's analog-to-digital converters (DACs).

*Controller*
Capturing of the sensor data is done by an *Arduino Pro Mini* microcontroller (3.3 Volt, 8 MHz) equipped with an *HC-05* serial Bluetooth module. Power is provided by a lithium polymer battery with voltage booster circuit.The microcontroller sends all sensor data via Bluetooth Serial Port Profile (BtSPP) to any connected system with approximately 100 Hz resolution.

## Exploration
In order to capture preliminary real-world data, the insole is inserted into a shoe (sneakers, left foot, shoe size EU 45) and tried on. Having a thickness of around 5mm the insoles decrease the space available inside the shoe, which makes the shoe fit tighter, but is still considered comfortable to wear. The flexible foam material still allows the foot to be actuated as usual. Attached to the shoe tongue, the microcontroller sends its data to a computer running a python data logger. No wearable device is controlled at this time, since this experiment is solely used to check the signal fidelity v

While a participant (age 32, male, no sports) stands in place, walks and sits down, the sensor data reflects the force distribution changes by showing high values while standing, oscillation while walking (see Figure 2) and low values while sitting.

While sitting on a chair the participant is asked to actuate each sensor individually 4 times in a row. Without prior training, the participant is able to make each individual sensor reading spike (see Figure 3). Note: The capacitive raw values use a smaller scale to handle the higher dynamic range, but the spikes are still visible above the base line.

The data shows that actuation of the sensors (even individual toes) can be achieved and detected by software. Still there is some cross-talk between the readings, which is considered to be addressed by further training, hardware design and/or algorithmically.

Based on these (and other) readings, a toe gesture concept is being designed and evaluated. This is still in progress while this paper is being published. Further research should focus on ease-of-use and fatigue resulting from extensive use of the system and its gestures.

## Signal Processing

The raw data is still very noisy: The capacitive readings suffer from the issues described earlier, resulting in highly dynamic data with different ranges and zero offsets, as well as static noise. To counter this, several signal processing steps are carried out on the raw data (filters, thresholds etc.). The resulting values are normalized, 0-based, band-passed delta values (see Figure 4).

This allows for the gesture recognition algorithms to work on clean data. The actual algorithm is still being worked on by the time of this publication.

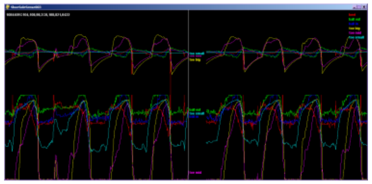


**Figure 4.** Screenshot showing processed data (top) and raw sensor data (bottom)

## Discussion

Since this project is still work in progress, there are still several open questions and challenges to be resolved:

- How to create a "gesture alphabet" that is easy to learn and to perform?
- How to robustly detect in different situations?
- What forms of feedback are possible?
- How much mental load does the system cause?
- Are there negative influences on posture?
- How can other sensor data (gyroscope) improve the system?

## References


[1] 3L Labs Footlogger. http://www.footlogger.com/ Accessed on January 4th 2014

[2] Ashbrook, D., Baudisch, P., & White, S. Nenya: subtle and eyes-free mobile input with a magnetically-tracked finger ring. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM Press (2011), 2043-2046.

[3] Bailly, G., Müller, J., Rohs, M., Wigdor, D., Kratz, S. ShoeSense: a new perspective on gestural interaction and wearable applications. In *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems*, ACM Press (2012), 1239-1248.

[4] Matthies, D. J., Müller, F., Anthes, C., Kranzlmüller, D. ShoeSoleSense: proof of concept for a wearable foot interface for virtual and real environments. In *Proceedings of the 19th ACM Symposium on Virtual Reality Software and Technolog*y, ACM (2013), 93-96.

[5] Nike Hyperdunk+. http://www.nike.com/de/de_de/c/basketball/nike-basketball-hyperdunk-plus Accessed on October 5th 2013

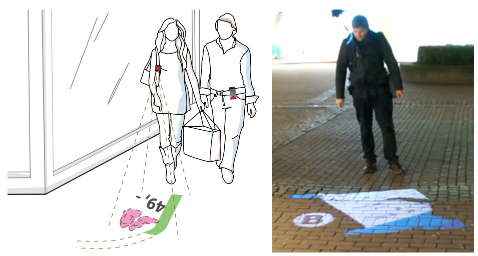
[6] Pebble Smart Watch http://www.getpebble.com/ Accessed on January 5th 2014

[7] Sensoria Fitness Socks. http://www.sensoriafitness.com/ Accessed on January 1st 2014

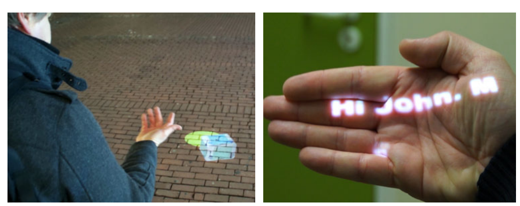
[8] ur Réhman, S., Khan, A., Li, H. Interactive Feet for Mobile Immersive Interaction. In *Proceedings of ACM International Workshop MobiVis at MobileHCI'12*, 2012.

# Peripheral Interaction On-The-Go

**Christian Winkler**
Ulm University
James-Franck-Ring
89081 Ulm, Germany
christian.winkler@uni-ulm.de



(a) Vision (b) Peripheral display




(c) Floor interaction (d) Hand interaction

**Figure 1:** (a). The vision: a wearable peripheral display (e.g., on the floor). (b) A user serendipitously discovers information. (c) The user has received a text message and picks it up from the floor. (d) The scrolling message text is read in the user's hand.



## Abstract

This paper assesses, discusses, and presents first solutions, to the challenges of Peripheral Interaction on-the-go. The on-the-go scenario is substantially different to previous peripheral interaction as the space for display, interaction, and sensing is much more confined.

## Author Keywords

Peripheral Interaction, Peripheral Display, Implicit Interaction, Personal Projection

## Introduction

Peripheral interfaces are deeply rooted in the vision of calm and ubiquitous computing. Without peripheral interaction, the original vision of using dozens of computers in our environment simultaneously would never be able to come true – at least not without putting excessive demand on the user. Only by providing the right set of implicit, casual, and active interactions and seamless transitioning in-between, we will be able to leverage humans' abilities for multitasking, which especially lie in parallel processing of different senses and actuators.

In recent years we have seen a lot of great work on peripheral display and interaction. Most of them focused on static scenarios like office work and not on mobile scenarios as there was not much digital information available on-the-go. With the emergence of smartphones, constant connectivity, and all sorts of cloud-based information services, the amount of data imposed on the user on-the-go has drastically increased. Many of the techniques used in static setups assume a known environment not available in the mobile scenario. For instance, there are no commonly available smart artefacts in users' mobile environments that could act as ambient displays. Smartphones that are carried in pockets or bags have only very limited capabilities in form of vibration or audio for ambient alerting. Upcoming smartwatches allow to reach to the device much quicker and can be instrumented to sense the user's context (e.g., [3]), but are still not in the visual periphery of the user on-the-go.

In the following the inherent challenges for peripheral interaction on-the-go are presented as well as some possible solutions to such as implemented in the *Ambient Mobile Pervasive Display* [5].

## Challenges of Interaction On-The-Go

The following challenges especially distinguish peripheral interaction on-the-go:

- The user does not maintain a known position: In traditional scenarios of peripheral interfaces the peripheral devices, be it displays or smart artefacts, maintain their position. The user can be assumed to take a similar position whenever interacting with the device. The primary tasks and positions are often well known and thus good places for peripheral display are known as well. In the on-the-go scenario, the current context of the user is not obvious and the environment might change quickly. Tracking of the user and the environment is required to compute both the right time intervals and suitable positions for peripheral display.
- In traditional scenarios, the rooms, displays, or smart artefacts can be instrumented to facilitate tracking of the user's context. On-the-go, the user must be instrumented to different degrees to achieve the desired context or interaction sensing.
- The user is in motion and might have only one or even no hand available for interaction. Techniques to display as well as to interact with peripheral information have to consider this and adapt to changing situations and requirements.
- Peripheral information always bears the risk to disrupt users from their primary tasks. While this is troublesome at most in indoor scenarios, it may easily become dangerous on-the-go if the primary task is crossing a street or setting foot on elevated stairs.

## The Ambient Mobile Pervasive Display

In this section we want to highlight three aspects of the Ambient Mobile Pervasive Display (AMP-D) [5] that contribute to the field of Peripheral Interaction and address some of the aforementioned issues. AMP-D is a wearable multi-display system that provides a pervasive window into the user's virtual information world on the floor. Unlike smartphones which have to be taken out to be operated, the AMP-D display is constantly available through constant personal projection. Therefore it is suited for peripheral alerting to many kinds of public or personal information that is available via the user's connected smartphone. Additionally, many information is not only visualized, but can be transfered from the floor to the user's hand (back and forth) using gestures to deal with the content in the hand or on the connected smartphone. AMP-D achieves this multi-display setup by means of a shoulder-worn projector-camera system that

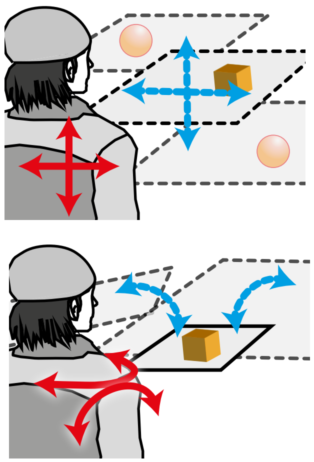


**Figure 2:** The virtual window follows the user's movement (top) and orientation (bottom).

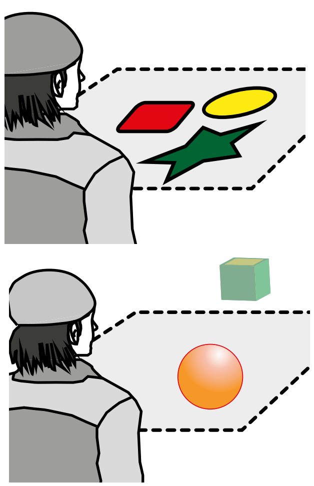


**Figure 3:** 2D World Graffiti (top), spheres and boxes as interactive elements (bottom)

measures the distance to the floor, surrounding walls, and the user's primary hand to deliver precise, perspectively aligned 3D augmentations on these surfaces (cf. [5]).

*AMP-D's Support for Mobile Peripheral Interaction*
*Pervasive and Ambient Floor Display*
To provide a mobile peripheral display, the floor is well suited since it is the only space that is always existent on-the-go. Further it is easy to glance at quickly and most of all, the floor display lies in the visual periphery of the user. Research on peripheral vision and cognitive psychology offers evidence that peripheral vision supports a separate cognitive channel, thereby reducing overall cognitive load [4]. More importantly, the effect of tunnel vision supports users in effectively blending out unnecessary information in the periphery when their cognitive load is high [2]. Inversely, when users' cognitive load is low, the display supports the serendipitous discovery of new information. Thus, AMP-D projects the permanently available display on the floor, yet content is only displayed when required.

AMP-D refrains from including any typical GUI elements such as windows or buttons on the display. Instead, the projection only shows a projected window into the user's virtual world, i.e. invariably, all projected content is clearly located in the worldwide coordinate system. This concept builds on Spatial Augmented Reality as opposed to the standard display-fixed presentation. In the context of projections, it feels like uncovering the virtual world with a spotlight. The system tracks users' movement and orientation to provide the corresponding illusion (Figure 2).

*Information Space: World Graffiti, Boxes, and Spheres*
To make the type of information discernible in the user's periphery, the virtual world of AMP-D consists of only two distinct types of visualizations: two-dimensional *World Graffiti* and two three-dimensional objects; *boxes* or *spheres* (Figure 3).

The two-dimensional graffiti is a stationary texture on the ground. Its flatness indicates that it is not meant to be interacted with. In contrast, the three-dimensional box and sphere items indicate that they are supposed to be interacted with.

Interactive items (boxes and spheres) typically lie at static places. If they are new and supposed to have an ambient alerting impact on the user (e.g. a notification), they roll into the user's field of view. If the user is currently moving, they further accompany the user for several seconds before coming to rest.

Boxes and spheres have defined content types which the user can quickly recognize from their different textures. Additionally, new boxes the user has not yet interacted with, carry a yellow border. In this manner, unlike with the use of ambient vibration alerts in smartphones, the user can quickly discern the type and novelty of new notifications by just glancing at the projection.

To further interact with the box or sphere, and change from peripheral vision to active interaction, users use their bare hands which are tracked by the system. By reaching out with their splayed hand towards the object, a green selection disk appears in the projection. It acts as hand extension that can be moved beneath the object of interest. By closing their fingers, the user selects the object (picks it up) and the object performs a jump animation into the user's hand (Figure 4). When picked up, many objects can disclose more sensitive information. Message boxes, for example, can show a picture of the sender of the message. Hand gestures allow the user to

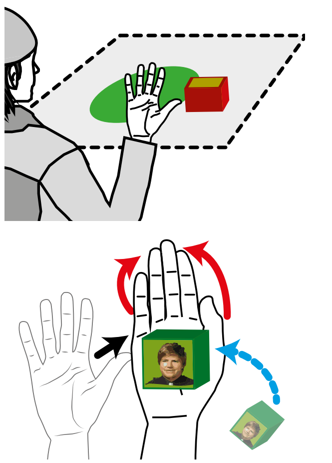


**Figure 4:** Object selection (top) and pick-up of objects by moving the fingers of the hand together (bottom).

interact further with the content. By turning the hand 90 degrees towards the center of the body, the user switches to *reading mode*. The box held in the hand shrinks and a preview of the content is displayed. For instance, a text message or the subject of an email as scrolling text. Finally, users have two options how to proceed with the object: By splaying out their fingers again, the item falls down back to the floor in front of them. Or, by performing a gesture as if to throw the item over one's own shoulder, the item is removed from the virtual world. Because the user is moving, many ordinary gestures that inhibit movement do not work. Gestures based on hand postures, like the ones presented, work best, followed by gestures that only inhibit horizontal movement.

*History and Overview through Implicit Interaction*
The concept of spatial augmented reality also allows for implicit and peripheral interaction with AMP-D . The implicit revealing or hiding of information using body motion can be used to look up upcoming content or to revisit past content. For instance, when a user recognizes content on the floor projection too late, walking a few steps back or just turning around will bring the item back into the projected window. Similarly, when users share their foot trails as World Graffiti, they can revisit them later, e.g. to find their way back to their car. As opposed to that, for instance, tilting the projection far ahead during navigation tasks allows users to preview directions further ahead. Results from a study by Billinghurst et al. [1] indicate that people can easily navigate and relocate spatially augmented information as they are used to the interaction from real life.

*Possible Improvements to Advance Peripheral Interaction*
AMP-D's support for implicit or peripheral interaction is limited to body movement at the moment. It is interesting to think of gestures that are explicitly designed to work in the user's periphery. A waving gesture, for instance, would be nice to make items in the periphery tumble away. But at the same time these gestures must be robust enough that they are not performed accidentally.

## Conclusion

The paper presented some initial solutions to peripheral display and interaction on-the-go, which will be necessary to fulfill the future vision of ubiquitous computing, but at the same time entails a lot of new challenges that go beyond traditional peripheral information systems for confined spaces.

## References


[1] Billinghurst, M., Bowskill, J., Dyer, N., and Morphett, J. Spatial information displays on a wearable computer. *IEEE Computer Graphics and Applications 18*, 6 (1998), 24–31.

[2] Costanza, E., Inverso, S. A., Pavlov, E., Allen, R., and Maes, P. eye-q: eyeglass peripheral display for subtle intimate notifications. In *Proc. of*, MobileHCI '06, ACM (2006), 211–218.

[3] Slawik, B. Micro manage me! - peripheral context annotation for efficient time management. In *Proc. of the first workshop on Peripheral Interaction: Embedding HCI in Everyday Life at Interact 2013*, Doris Hausen, Saskia Bakker, Elise van den Hoven, Andreas Butz, Berry Eggen (2013).

[4] Treisman, A. Preattentive processing in vision. *Computer Vision, Graphics, and Image Processing 31*, 2 (Aug. 1985), 156–177.

[5] Winkler, C., Seifert, J., Dobbelstein, D., and Rukzio, E. Pervasive Information through Constant Personal Projection: The Ambient Mobile Pervasive Display (AMP-D). In *Proc. of CHI'14*, ACM Press (2014).