Interacting with Computers 24 (2012) 119–130

Contents lists available at SciVerse ScienceDirect

Interacting with Computers

journal homepage: www.elsevier.com/locate/intcom

Acting by hand: Informing interaction design for the periphery of people's attention ☆

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ARTICLE INFO

Article history:
Received 18 April 2011
Received in revised form 3 April 2012
Accepted 8 April 2012
Available online 20 April 2012

Keywords:
Interaction design
Periphery
Attention
User-centered design
Tangible interaction
Embodied interaction

ABSTRACT

Interactions in and with the physical world have enabled us to perform everyday activities in the periphery of our attention. Even though digital technologies are becoming increasingly present in the everyday environment, interaction with these technologies usually requires people's focused attention. In the realm of the vision of calm technology, we think that designing interactions with the digital world inspired by our peripheral interaction with the physical world, will enable digital technologies to better blend into our everyday lives. However, for such interaction design to be effective, a detailed understanding of the everyday periphery is required. In this paper, we therefore present a qualitative study on everyday activities that may take place in the periphery of the attention. We provide a broad range of examples of such everyday activities and cluster them to present the conditions under which they may be performed peripherally. Furthermore, we discuss how our findings may be relevant for the design of peripheral interactions with digital technologies, and present two conceptual designs that are based on our findings.

1. Introduction

Today, we see that digital technologies are being integrated in everyday objects and environments. These developments have lead to wide discussions on how the computer of the future can fit into everyday life in the physical world. As a result, several areas of research aim at developing and evaluating interactions with digital technologies, which are inspired by interactions in the physical world. Embodied interaction (Dourish, 2001) as well as tangible user interfaces (Ullmer and Ishii, 2000) for example aim at leveraging motor abilities and cognitive mechanisms in interaction with technology, by using designated physical artifacts. Weiser (1991) discusses the computer fading into the background, not only by 'hiding' technology in artifacts or surroundings, but also by enabling users to perceive and interact with computers in the background, so that "we are freed to use them without thinking and so to focus beyond them on new goals" (Weiser, 1991, p. 3).

Weiser's vision seems highly interesting from a ubiquitous computing point of view. Traditionally, human computer interaction happens through screens, keyboards and mouses, interaction methods that usually require the user's focused attention. In the physical world however, many interactions take place without focused attention. Tying your shoelaces, switching the lights on, chewing your breakfast; such activities can easily be performed without direct attention. To fit computing technology in everyday life, traditional types of interfaces will thus not be effective. Weiser and Brown (1997) therefore envisioned *calm technology*; "technology that engages both the center and periphery of the attention and in fact moves back and forth between the two" (Weiser and Brown, 1997, p. 79). In other words, calm technology aims at leveraging human attention abilities, which enable us to perform certain activities without direct attention, in interaction with digital technologies. In the realm of this vision, several researchers have developed and evaluated systems that display information in the background or *periphery* of the attention (Mynatt et al., 1998; Eggen and van Mensvoort, 2009; Ishii et al., 1998; Matthews et al., 2004).

Apart from perceiving information in the periphery of the attention, we also see many everyday examples of physical *actions* that may take place in the periphery of the attention. If such actions in the physical world can be performed without direct attention, it could be interesting to investigate if we can similarly design peripheral interactions with the digital world. Since these examples mostly involve bodily actions, we think that tangible (Ullmer and Ishii, 2000; Hornecker and Buur, 2006; Mazalek and van den Hoven, 2009; Shear and Hornecker, 2010) or embodied interaction (Dourish, 2001) would be suitable interaction styles for such systems. Tangible interaction (Ullmer and Ishii, 2000; Hornecker

☆ This paper has been recommended for acceptance by Michael Muller.

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http://dx.doi.org/10.1016/j.intcom.2012.04.001

and Buur, 2006; Mazalek and van den Hoven, 2009; Shear and Hornecker, 2010) combines the benefits of both physical and digital world through the use of physical artifacts to represent as well as control digital data. Embodied interaction, as envisioned by Dourish (2001), overlaps with tangible interaction as it also origins in the view that tangibility is a key factor in interaction with the physical world. Embodied interaction however takes a broader stance by envisioning meaningful interaction with technology inspired by not only physical but also social phenomena of everyday life (also see Shear and Hornecker, 2010 for differences and similarities between tangible and embodied interaction).

In order to design interactions inspired by human attention processes in the real world, it is required to have an understanding of how human attention abilities are used in everyday life. Therefore, in this paper we present an extensive qualitative study on peripheral actions in everyday situations, in order to inform the design of interactive systems that aim at leveraging these abilities. But first we will discuss attention theory as well as related research in the area of calm technology.

2. Attention theory

In the areas of psychology and neuroscience, several theories of the cognitive processes that underlie human attention have been developed. Based on these theories, we now present our current understanding of human attention abilities.

Literature distinguishes two main functions of attention, *selective attention* and *divided attention* (Sternberg, 1999; Wickens and McCarley, 2008). Selective attention theory describes attention by analogy with a mental filter, which enables selectively focusing the attention on one stimulus while intentionally ignoring others (Sternberg, 1999). As suggested by models of selective attention, this mental filter is not only influenced by choice, but also by *salience* (Pashler, 1998) as well as by a cognitive process called *priming* (Cherry, 1953; Treisman, 1964). A sudden movement for example has such salient physical properties that it immediately passes the filter and is thus attended to. Furthermore, certain highly relevant stimuli are more likely to pass the filter as a result of priming (Treisman, 1964). A common example of a primed stimulus is one's own name; when one's own name is mentioned in a distant conversation, this is likely to be noticed.

Divided attention theory finds its basis in the observation that we are, under certain circumstances, able to perform multiple tasks at once (Sternberg, 1999). Models of divided attention describe attention as a finite amount of mental resources that can be divided over different activities. The two functions of attention (selective and divided attention) are not mutually exclusive; both selectivity and resource allocation characterize the attention process (Pashler, 1998). Selectivity primarily plays a role when attention is devoted to sensorial stimuli, whereas resources can be allocated to physical activities, thought processes and sensorial activities. In other words, selective attention theory seems to overlap with divided attention theory in the sense that a selective filter may determine the availability of sensorial activities to which mental resources can be allocated. Since we are particularly interested in physical activities that take place in the periphery of the attention, the research presented in this paper is positioned in divided attention theory.

An influential model which describes attention as the allocation of mental resources is presented by Kahneman (1973). This divided attention model centers around a number of potential activities that one can perform as a result of (sensorial or intellectual) information input. These activities may be bodily activities (e.g. running), cognitive activities (e.g. thinking), sensorial activities (e.g. listening to music) or combinations of these types (e.g. having a conversation, which requires bodily, cognitive and sensorial activities). Kahneman (1973) speaks of *potential activities* since not all these activities will be performed at the moment: activities can only be performed when mental resources are allocated to them. As a limited amount of mental resources is available, not all potential activities can be performed at once. The amount of mental resources required for each activity depends on different aspects of the activity, namely *difficulty* of the task and *automaticity*. Automated processes (Wickens and McCarley, 2008) are those that one is very experienced in and therefore require only few mental resources. Driving a car is a common example of an automated process; once experienced in driving a car one can do all kinds of activities simultaneously, e.g. making a phone call, eating a sandwich or listening to music. Kahneman's model (Kahneman, 1973) assumes that a limited amount of mental resources is available to allocate to, and thus perform, potential activities. When such activities require few resources, multiple tasks can be performed at once.

Divided attention theory is frequently studied in experiments on multitasking (Wickens and McCarley, 2008; Wickens and Hollands, 2000; Gladstones et al., 1989). In such experiments, participants are usually asked to perform two high attentional tasks, e.g. dialing a phone number while driving (Wickens and McCarley, 2008). Contrary to such studies however, we are interested in low-attentional and most likely non-crucial activities that are performed simultaneous to everyday main activities. Although many multitasking studies do not show evidence for multitasking being more efficient compared to single task processing (Gladstones et al., 1989), we believe that leveraging the human ability to perform low-attentional tasks in the periphery of the attention may benefit users on a different level. We envision the added value of our approach not to be in the efficiency of performing tasks, but merely in the experience of not needing to focus attention on interactions with technology and therefore seamlessly fitting them in the user's everyday routine. This may enhance the experienced fluency with which this everyday routine can be carried out.

In Fig. 1, we present an illustrative overview of our current understanding of the human attention process which is largely based on Kahneman's model (Kahneman, 1973). This overview is primarily meant to structure our understanding of divided atten-

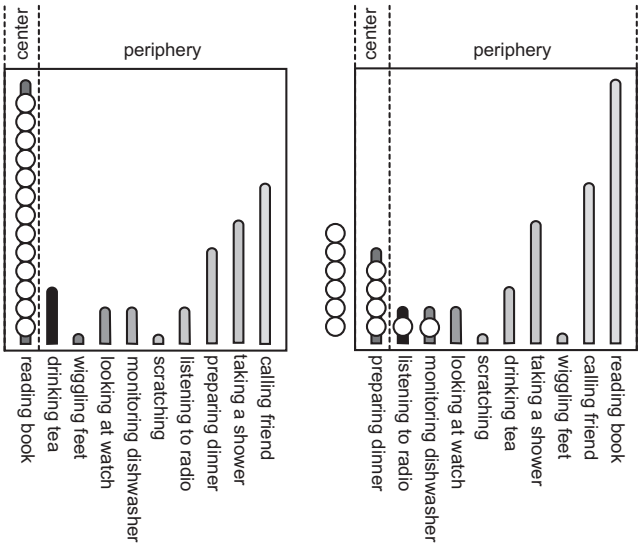

Fig. 1. Illustration of the center and periphery of the attention. The division of mental resources during a high attentional task (left) and during a combination of low attentional tasks (right). Vertical bars represent potential activities that are performed when mental resources (white circles) are allocated to them.

tion theory as well as to establish a working definition of the periphery of the attention (also see Bakker et al., 2010). In line with Kahneman's model (Kahneman, 1973), our illustration centers around potential activities (that one can undertake but that are not necessarily being performed at the moment), illustrated as vertical bars. The height of these bars indicates mental resource demand, which can depend on difficulty or automaticity of the activity. Mental resources, which can be allocated to potential activities, are illustrated as white circles. As shown in Fig. 1, all resources may be allocated to one, high attentional activity, such as when being highly engaged in reading. However, resources can also be allocated to multiple low attentional tasks, such as when preparing dinner while also listening to the radio and monitoring the progress of the dishwasher.

As suggested in both selective and divided attention theory, certain activities may be more likely to be performed than others. Shallice and Burgess (1993) describe the *supervisory attentional system*, a cognitive mechanism that activates schemata of action or thought processes which increases the probability that those processes are executed. For example, when one has just prepared a cup of tea and is holding it in the hand, the activation of action schemata increase the likelihood that the activity of 'drinking tea' is performed. When one is reading a book while the cup of tea is standing on a side table, a number of potential activities will be available; apart from *drinking tea*, this person may also intend to *call a friend* on that day or to *take shower* in the coming hours. Clearly not all these potential activities can be performed at the moment. However, given the action schemata that are activated at that moment, the potential activity of drinking tea has a much higher likelihood of receiving resources compared to calling a friend or taking a shower. The likelihood of potential activities being performed is indicated by the brightness of the color of the bars in Fig. 1. Activities illustrated as darker bars are more likely to be selected compared to those illustrated as lighter bars.

Apart from their likelihood of being performed, certain activities may also be more suitable to be performed at certain moments. This relates to the Multiple Resource Theory (Wickens and McCarley, 2008), which describes the influence of the type of activities on people's ability to perform them simultaneously. For example, it is rather difficult to drive a car and read a book at the same time, but driving while listening to the same book on tape is possible. As described by Multiple Resource Theory (Wickens and McCarley, 2008), bodily activities are more easily performed simultaneous to sensorial activities compared to performing two bodily activities at the same time. The resources illustrated in Fig. 1, can therefore not arbitrarily be divided over the potential activities, but the division depends on the types of activities involved.

In the area of calm technology, the *periphery* is described as "what we are attuned to without attending to explicitly" (Weiser and Brown, 1997, p. 79). In psychology literature however, the word periphery is used in visual perception research, indicating the parts of vision that occur outside the center of the visual field (Wickens and Hollands, 2000). As we understand the attention process as the division of mental resources over potential activities, we see the *center* of the attention as the one activity to which most resources are allocated and the *periphery* of the attention as all other potential activities, see Fig. 1.

Although our illustration of the center and periphery of the attention in Fig. 1 seems static, the attention process is highly dynamic as the division of resources over different activities is subject to constant change. For example, when the radio is playing music while one is preparing dinner, the activities of listening to the radio and preparing dinner may constantly shift between the center and the periphery of the attention. Also the resource demand and likelihood of selection of activities may continuously change. For example, the activity of preparing dinner consists of several smaller tasks of various resource demands. Furthermore, while cutting the vegetables, one may be reminded that a certain knife is currently in the dishwasher, increasing the likelihood of performing the activity of monitoring the dishwasher. The height and brightness of the colors of bars presented in Fig. 1 are therefore no absolute representations of resource demand or likelihood, but are included merely to illustrate our understanding of the attentional process.

As not all potential activities can be performed at one moment, many unperformed potential activities will always be in the periphery of the attention. For the clarity of this paper however, we will only look into those peripheral activities that are being performed, be it with limited amount of mental resources.

3. Physical and peripheral interactions

Several (research) examples are known of designs that aim at engaging the periphery of the user's attention. Peripheral displays for example "allow a person to be aware of information while she is attending to some other primary task or activity" (Matthews et al., 2004, p. 247). Motion Monitor (Matthews et al., 2004) is a peripheral display that uses colored light to indicate activity at a remote location. Data Fountain (Eggen and van Mensvoort, 2009) is a more physical design; a full size water fountain that displays the relative values of the Dollar, Euro and Yen through the height of water jets. The Dangling String (Weiser and Brown, 1997) is a background audiovisual display of the network activity in an office. Audio Aura (Mynatt et al., 1998) is an example that uses sound to subtly provide information relevant to office workers. All these designs aim at displaying potentially interesting information in a non-obtrusive way, enabling users to monitor it in the periphery of their attention, but also to focus on it in the center of the attention when relevant or desired.

Although such systems valuably leverage human (selective) attention abilities in interaction with technology, we are also interested in informing the design of *physical* interactions that can potentially be performed in the periphery of the user's attention. In recent years, the area of tangible and embodied interaction has been rapidly developing. Early research in this area focused on the development of *Graspable User Interfaces* (Fitzmaurice et al., 1995); physical artifacts called 'bricks' that could be used to directly manipulate digital data. Later work involved research on *Tangible User Interfaces* (Ullmer and Ishii, 2000), also referred to as *Tangible Interaction* (Hornecker and Buur, 2006; Mazalek and van den Hoven, 2009); an interaction style that includes physical artifacts that both represent as well as enable the user to control digital data. *Embodied interaction* (Dourish, 2001) takes a broader stance by focusing on the "creation, manipulation, and sharing of meaning through engaged interaction with physical artifacts" (Dourish, 2001, p. 126), which can be realized by combining "tangible and social computing". Numerous examples of designs in these areas are known in several different application areas such as entertainment (Raffle et al., 2004; van Boerdonk et al., 2009), education (Zuckerman et al., 2005; Antle et al., 2007), musical performance (Jordà et al., 2007; Zigelbaum et al., 2006) and office work (Ullmer and Ishii, 1997), to name but a few. In line with the objectives of these designs, most of these interactions are designed to be in the center of the user's attention.

Some examples are known that combine peripheral monitoring of information with tangible interaction. AmbientROOM (Ishii et al., 1998) for example uses a background soundscape to convey information about emails or the stock market, but such auditory information can also be requested by opening a glass bottle that 'contains' it. IrisBox (Eggen et al., 2008) is a design with which

users can physically indicate their availability. The design provides continuous background sounds representing the availability of friends or family members. Similarly, Hangsters (Peek et al., 2009) is a design that includes physical tokens as representations of instant messaging contacts. These tokens provide a visual peripheral display of the status of these contacts, but can also be manipulated to initiate a conversation or respond to a conversation request. Even though all these designs can be monitored in the periphery, the actual interaction (requesting information, indication your availability or initiating a conversation) will likely take place in the center of the user's attention.

Only very few examples were found that aim at enabling physical interaction in the periphery of the user's attention. A system called "Whack Gestures" (Hudson et al., 2010) is described as "inexact and inattentive interaction" (Hudson et al., 2010, p. 109); an interaction style usable for limited input and that requires minimal attention. With Whack Gestures, users can respond to a cue on their mobile phone or PDA by firmly striking the device, while it is still in their pocket. Edge and Blackwell (2009) present 'Peripheral Tangible Interaction'; digitally-augmented physical tokens that can be manipulated on the side of the workspace outside the visual focus. This allows office workers to track or update task progress in the periphery of the attention.

Clearly only little research is available on interactions that take place in the periphery of the user's attention. We therefore believe that thorough investigation of everyday peripheral actions could inspire the design of interactive systems that can be used in the periphery of the attention.

4. Everyday periphery study setup

In the previous section, we described our theoretical understanding of the attention process, involving the allocation of mental resources to potential activities. This understanding is based on psychology literature, describing controlled experiments in specific settings that usually involve a mixture of high attentional tasks, such as when driving a car or flying an airplane (Wickens and McCarley, 2008; Wickens and Hollands, 2000). In most everyday situations however, the division of resources will be very diverse, including both high and low attentional tasks, and likely not all resources will be 'in use' at any moment. Knowledge regarding how to design interactions that can take place in the periphery of the attention and that are meant for the everyday context can therefore hardly be gathered through such controlled studies. In order to lay-out and verify a design space for such interaction with technology in an everyday context, we set up a qualitative user study on how the periphery of the attention is 'used' in everyday life.

The main goal of this qualitative study was to gain a broad and rich overview of examples of everyday activities that can be (completely or partially) performed in the periphery of the attention. These examples were intended to provide us with a better understanding of the *preconditions* that enable activities to take place in the periphery of the attention, which could be useful for the design of similar interactions with technology. Although this study dealt with both peripheral perceptions and actions, the scope of this paper focuses on actions that may be performed in the everyday periphery of people's attention. The results of the perception element of our study are described in Bakker et al. (2012).

Most applied research on attention is meant to improve human performance of tasks that require a lot of mental resources (e.g. Wickens and McCarley, 2008; Wickens and Hollands, 2000). This seems a valuable approach since the efficiency of performing such tasks may be improved when human attention abilities are leveraged. However, as ubiquitous technologies are increasingly becoming present in our everyday private lives, and not only in professional situations, we are interested in investigating if and how attention abilities can be leveraged in the home environment. Contrary to many professional environments, the home seems a place where people are usually not highly concentrated. This entails that many activities performed in this environment require a low amount of mental resources and can therefore potentially be performed in the periphery of the attention. To gain new insights in the everyday periphery, we have therefore decided to focus our study on the home environment.

Since the aim of our research is to study everyday activities that are performed in the periphery of the attention, we are after activities people perform without paying much attention to them. By definition however, people will often not be aware of the fact that they perform these kinds of activities. Regular interviews will therefore likely not provide us with a reliable overview of peripheral activities. Observation could provide us with an overview of people's activities in the home environment, as well as an idea of activities that are performed in parallel, possibly indicating peripheral activities. Although observation may reveal certain information about physical activities, it may not provide reliable data about people's perceptions (e.g. what are people seeing, hearing, smelling). This was relevant for the perception part of our study that is outside the scope of this paper, but presented in Bakker et al. (2012). Additionally, the presence of an observer or recording-device in people's homes could intrude their everyday activities in such a way that these activities may become unrealistic. Furthermore, we expected that most interesting data would be gathered from people reflecting upon their own peripheral behavior rather than independent observers interpreting people's behavior. We have therefore decided to use the approach applied in the method 'context mapping' (Sleeswijk Visser et al., 2005), in which several methods are combined including interviews, discussions, diaries and video-recordings which are reflected on by participants. In context mapping studies, which are often conducted in design projects that aim at solving a specific problem or improving a specific experience, participants are 'sensitized' for the topic of interest before they are invited to take part in a creative group interview. Using this approach in our study would allow for participants to reflect on the way they 'use' their periphery in everyday situations over a period of time. This reflection period is intended to increase the participant's awareness of their peripheral activities and therefore make it easier to share and discuss in an interview with a group of participants. Furthermore, the different phases used in context mapping studies enable us to approach the rather complex topic of our study in several different ways, which may increase the richness of the information we gain about it. The two phases we used in our study are the *sensitizing phase* and the *discussion phase*.

4.1. Participants

Since we have not yet defined the target group for our future designs, we have selected a diverse group of participants for our user study. We decided to recruit 13 participants in total, so that we could divide them over three groups that are of suitable size for the discussion phase of our study. When having only one discussion session, potentially dominant participants could have too much influence on the results (Sleeswijk Visser et al., 2005), we therefore decided to organize three separate sessions in the discussion phase. The participants were recruited by word of mouth and they volunteered without receiving a financial compensation. The 13 participants, none of whom were familiar with the topic of research, differed in age, gender and occupation (see Table 1 for an overview). We furthermore took family living situation into account when selecting the participants, as this factor may likely

Table 1
Overview of the demographics of the participants in our study.

	Gender	Age	Occupation	Family living situation
P01	M	23	Design researcher	Alone
P02	M	25	Mechanics researcher	Partner
P03	F	27	Teacher	Partner
P04	M	29	Teacher	Partner
P05	M	30	Software engineer	Alone
P06	F	31	Project manager	Partner and 1 child (0)
P07	F	34	Housewife	Partner and 3 children (1, 4 and 6)
P08	F	35	Student advisor	Partner and 2 children (0 and 2)
P09	F	37	Psychologist	Partner and 2 children (9 and 10)
P10	F	52	Housewife	Partner and 1 child (16)
P11	M	58	Journalist	Partner
P12	F	58	Hydrology engineer	Partner
P13	M	60	Food engineer	Partner

influence the everyday activities people perform in their home environments. For example, the everyday routine of a parent with children living at home will largely differ from a person who lives alone. As evident from Table 1, most of the participants were highly educated. We saw this as an advantage; they may be used to abstract thinking, which can be helpful in our study and which is regarded to be useful in context mapping studies (Sleeswijk Visser et al., 2005). Due to personal circumstances, two participants (P07 and P09) could only participate in the sensitizing phase. In the discussion phase of the study, participants were grouped in three groups of three or four. In two of these groups, the participants did not know each other, whereas in one group three participants knew each other as they lived in the same neighborhood.

4.2. Pilot study

To evaluate the experimental setup, we ran a pilot study with two female participants (ages 29 and 31) who were both researchers, one of whom lived alone and one with her partner. Both performed the sensitizing phase as well as the discussion phase. As a result, we found that some of the exercises used in the sensitizing phase were not explained specifically enough and therefore the examples of everyday peripheral activities we found were too broad. Possibly as a result of this, the pilot–participants had difficulty in discussing their peripheral behavior during the discussion session. To prevent these issues, we decided to refine the description of the sensitizing exercises as well as the instructions provided during the discussion phase.

4.3. Sensitizing phase

The aim of the sensitizing phase is to make the participants reflect on the way they use their periphery during everyday activities in the home environment. As this reflection process will likely take some time, this phase lasted for a period of 1 week, which is the usual length of sensitizing phases in context mapping studies (Sleeswijk Visser et al., 2005). In the beginning of this week, the participants were given a booklet with six exercises as well as some materials that were needed to perform these exercises (see Fig. 2). As we were interested in activities performed in the home environment, these exercises were to be executed in the home of the participant at a moment of choice. Each exercise was meant to take about 10 min and participants were instructed to perform no more than two exercises in 1 day, to enable time for reflection.

The exercises in the sensitizing package were meant to trigger the participant to explore and think about the kinds of activities he or she performs without directly paying attention to them. For example, participants were asked to draw a timeline of all activities they performed in the last 2 h or to record a video of an everyday activity and reflect on their own (peripheral) behavior while looking at this video. The pages on which participants performed the exercises in the booklet intentionally included lots of open space, allowing the participant to put their thoughts on paper in a way they preferred, e.g. by including drawings or leaving comments. See Fig. 3 for an impression of how the participants used the booklets while performing the exercises.

Fig. 2. The sensitizing package.

4.4. Discussion phase

After individually performing the sensitizing exercises in their own homes, we invited the participants for a creative interview session in groups of three or four. Sharing and discussing experiences with others was expected to result in a richer and broader range of data compared to individual interviews. The three group sessions lasted about 90 min each and were lead by the first author. The sessions took place in a general meeting room where video recordings were taken to enable analysis. The sessions were divided into three separate parts; a group interview and two exercises. The second of these exercises falls outside the scope of this paper, but is elaborately described in Bakker et al. (2012).

The discussion phase started with a *group interview* consisting of open questions to stimulate discussion between participants. The aim of this interview was to gather everyday examples and

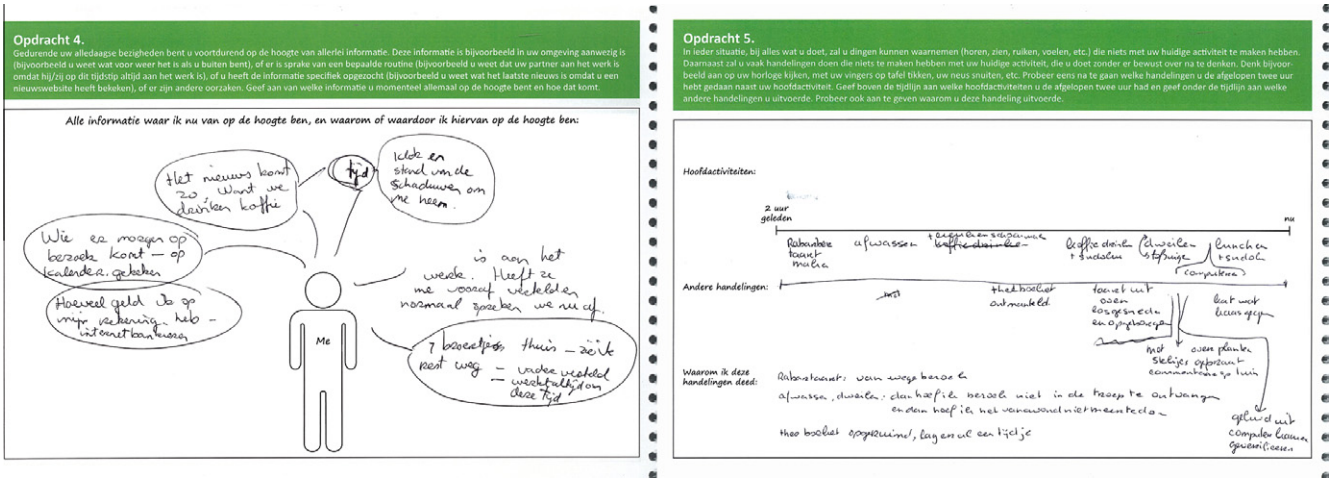

Fig. 3. Two filled out sensitizing exercises to give an impression of the way they were performed by different participants (in Dutch).

experiences of activities the participants can perform in the periphery of their attention. To ensure that they indeed talked about the periphery rather than the center of their attention, we steered our questions in such a way that they focused on activities that are performed apart from the main focus of attention. For example "When you are doing everyday activities at home, what are you doing that is not related to your activity?". Other questions that we used in the group interview included "Can you name examples of activities that you perform without being fully aware of it?", "Which activities can you perform with minimum attention and why do they require minimum attention?", and "Are there situations in which you are better able to perform such activities compared to other situations?".

After this open group interview, the participants were given an exercise that was meant to result in more specific and detailed examples of peripheral activities. In this exercise, which was called the *scenario exercise*, the participants were asked to make a detailed overview of an everyday activity they perform at home. They could choose the activity they described from six options we provided: cooking, having dinner or breakfast, personal hygiene activities, cleaning, reading or watching TV. First, the participants were asked to create a timeline describing a brief chronologic overview of the main actions taken during the selected activity. Secondly, the participants were asked to write down what other activities they performed during this activity. These other activities could be linked to the timeline (e.g. 'before cutting the vegetables, I always wash my hands'), or not (e.g. 'during breakfast, I usually think of my planning for the day'). These activities may indicate types of activities that can be performed in the periphery of the attention. After creating these scenarios, they were discussed in the group. Similar to the sensitizing exercises, we provided a sheet with ample open space. See Fig. 4 for two filled out examples of the scenario exercise, which show how different participants put their thoughts on paper.

4.5. Data analysis procedure

As a result of the sensitizing exercises, the group interview and the scenario exercise, we had gathered both handwritten and video data usable as input for qualitative analysis. In our study, we were mainly interested in finding out the role of the periphery of the attention in everyday situations in the home environment in order to inform the design of (peripheral) interactive systems that are to be used in that context. Since not much related research was available, we were looking for a broad range of examples of everyday peripheral activities. We analyzed the data using 'open coding' (Liamputtong and Ezzy, 2005) or 'conventional content analysis' (Hsieh and Shannon, 2005), which entails that data is clustered without a predefined elaborate coding scheme. Instead, detailed clusters emerged during the analysis.

In order to come to a diverse selection of examples, we used both the results from the sensitizing and discussion phase in our analysis, which is common practice in context mapping studies (Sleeswijk Visser et al., 2005). All handwritten and video data gathered in the study were transcribed verbatim and quotes were selected from these transcriptions that seemed to capture interesting examples or insights related to everyday peripheral activities. This led to a selection of 285 quotes, which could be simple statements (e.g. "I often play with my pen while reading") or richer explanations (e.g. "When I am cooking, I look at the clock very frequently for example to monitor how long the rice is already cooking. However, often I do not really register the time and one minute later I have already forgotten how long the rice was cooking").

To find common themes and overall results from these quotes, we set up a group clustering session in which three researchers took part: the first authors as well as two other researchers who had not been involved in the study before. Small pieces of paper that each contained one of the 285 quotes were divided among the three researchers. Since our research aimed at informing design processes, we were most interested in gaining insights in the *preconditions* that enable activities to take place in the periphery of the attention. We therefore asked the researchers to cluster their quotes in a way that would provide an answer to the question 'why does the described activity require little or no attention?'. The researchers started by individually clustering their quotes according to this question after which they compared their clusters. The differences in clusters were discussed and as a result, the three researchers agreed to an overview of clusters that captured the essence of the data.

When discussing the clusters in the group clustering session, we concluded that not only clusters describing different preconditions for peripheral activities were needed, we also thought it would be interesting to create an overview of the *types* of activities. Three main types of activities were seen: bodily activities (e.g. walking), cognitive activities (e.g. thinking) and sensorial activities (e.g. listening to the radio). Having an overview of which types of activities can potentially be performed in the periphery of the attention could provide a direction for the interaction style of peripheral interactive systems which can be relevant when

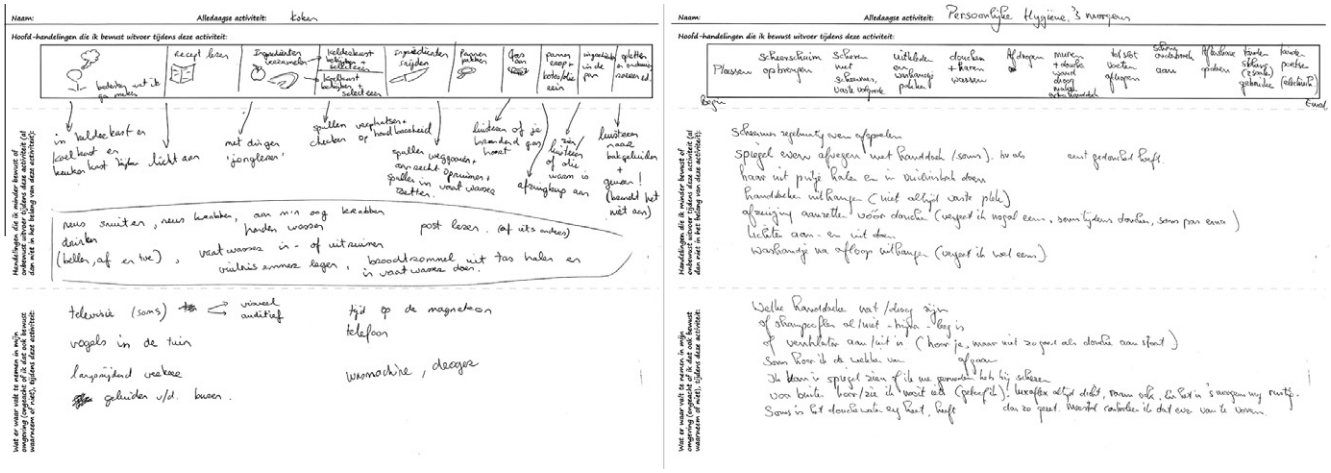

Fig. 4. Examples of the results of the scenario exercise (in Dutch).

designing such systems. To provide a valuable overview of the data, we therefore chose to group the quotes on a two-dimensional scale; one dimension indicating the type of activity and one dimension indicating why the activity requires little (or no) attention.

To determine the reliability of the clusters on the two dimensions that were established in the group clustering session, we asked two coders to cluster all 285 quotes according to these two dimensions. These two coders were the first author, as well as an independent second coder who had not participated in the group clustering session. After both coders had divided the quotes over the clusters, the divisions of quotes were compared and discussed. As a result, some quotes were moved between clusters to correct some mistakes. To determine the extent to which the two coders agreed in their clustering, we calculated Cohen's Kappa statistic, which provides the agreement between the two coders as a number between 0 and 1 (0 indicating no agreement and 1 indicating perfect agreement) (Siegel and Castellan, 1988). This resulted in a Kappa Coefficient of 0.81, a number that is generally regarded as high agreement between coders (Landis and Koch, 1977).

5. Findings

The objective of the qualitative study described in this paper is to gain an understanding of the way the periphery of people's attention is used during everyday activities in the home environment. More specifically, we were interested in everyday activities that require little or no attention and can therefore be performed in the periphery. This knowledge is needed to inform the design of interactions that could take place in the periphery of the attention. To gain this knowledge, we have selected 285 quotes from our qualitative data. These quotes describe activities that our participants performed with minimum mental resources. It is important to note that not all these activities are clearly peripheral according to our description presented in Fig. 1. For example, a participant mentioned to be thinking about his day while having a shower. In this example it is unclear to which of these two activities most resources are allocated. In fact, the division of resources over these two activities is likely to be constantly changing. So according to our own description of the periphery of the attention, having a shower will be in the periphery at one moment, and thinking will be peripheral the next moment, which can also be expected based on the dynamic nature of the overview we draw in Fig. 1. Since the main goal of our study is to inform the design of systems that can be interacted with in the periphery of the attention, we are interested in all activities that *can* be in the periphery of the attention, but also engage the center of the attention at certain moments, e.g. when this is relevant for or desired by the user. We are therefore confident that our findings provide a valid overview of potential peripheral activities.

The 285 selected quotes have been clustered to find common themes that give an impression of the types of everyday activities that may require little or no attention as well as why this is the case. In this section, we will discuss the results of this clustering.

5.1. Types of peripheral activities

The quotes gathered in our study all describe everyday activities that may be performed in the periphery of the attention. When clustering these quotes we distinguished three types of activities: sensorial activities, cognitive activities and bodily activities, which we subdivided in activities performed with the hands and other activities (e.g. those involving the whole body). Clearly, many activities may involve multiple types of actions, for example cooking will involve bodily actions, but seeing and thinking is likely also required to successfully perform these activities. To keep the overview of peripheral activities clear however, when clustering the quotes we looked at the main type of activity that is performed. Cooking is therefore considered a bodily activity that is mainly performed with the hands.

As a result of our clustering, we found that by far most activities described by the participants were bodily activities (204 out of 285 quotes). The majority of these bodily activities were performed with the hands (167 quotes). Table 2 provides an overview of the number of quotes in the clusters of the two dimensions 'type of everyday activity' and 'why everyday activities require little or no attention', which will be discussed in the next subsection.

5.2. Why everyday activities require little or no attention

To gain a better understanding of why everyday activities require little or no attention, we asked the participants several different questions. When asked to name activities that required little or no attention, we experienced that participants usually named *main* activities, such as cooking or ironing. Another approach we used however, was to ask participants which other activities they perform during everyday activities at home. When such activities can be performed alongside or during other activities, they can likely be performed in the periphery of the attention. As a response to these questions, participants naturally described *side* activities such as "while cooking, I often wash my hands". In the latter case,

Table 2
For each (sub-)cluster indicating why an activity required little or no attention, the number of quotes assigned by the first coder, categorized over the different possible types of activities. For example, the first coder found one quote that indicated a hearing activity that required little or no attention because it was done to rest or relax.

Why the activity required little or no attention			Type of activity									Total
			Sensorial activities					Cognitive activities	Bodily activities		Unclear	
			Hearing	Seeing	Smelling	Touching	Tasting		Hands	Other		
Main activity	Routine							2	61	25	3	91
	Resting/relaxing		1	7				8			5	21
Temporary side activity, internally triggered	Clear goal	Related to main activity	1	2				2	14		1	20
		Not related to main activity		12				3	36	6	5	62
	No clear goal			6					16	4	4	30
Temporary side activity, externally triggered			2						34	2		38
Ongoing side activity			4	2	1		1	8	6		1	23
Total			8	29	1		1	23	167	37	19	285

the described side activity (washing hands in the example) was used for clustering.

As a result of the group clustering session, we identified four main clusters that each describe a factor that pays a role in the amount of attention required for an activity. These four main clusters – (1) *main activities*, (2) *temporary side activities* that are *internally triggered,* (3) *temporary side activities* that are *externally triggered,* and (4) *ongoing side activities* – as well as the sub-clusters that were identified, will be discussed here in detail.

5.2.1. Main activities

The first cluster we found, describes *main activities* that require little or no attention. We see a main activity as the primary task that a person is performing, even though this may not require a lot of attention. In other words, one's main activity is the activity that would be written down if one was to keep a logbook of the day. For example when having dinner and thinking about the day planning at the same time, having dinner would be the main activity, even though thinking may require more mental resources at certain moments. In this cluster, we found 112 out of 285 quotes.

Most of these quotes (91 out of 112) described activities that required little or no attention because they are *routines*, activities in which one is very experienced and therefore do not require much thinking. The majority of these activities (61 out of 91) were bodily activities performed with the hands. For example one of the participants described ironing, "I sometimes need to pay a little attention to make sure that the clothes are laid down correctly, but I have done it so often that the rest of the time I am usually more focused on the TV than on the ironing itself". Another bodily activity that was named by several participants was taking a shower, for example "the ultimate example that hardly requires attention for me is taking a shower. When in the shower, every physical action goes automatically and in the meanwhile, I am still waking up and thinking about what my day will be like. I do not even notice how much time I spend in the shower, or forget if I already used the shampoo or not". Other examples of such bodily activities were cooking, eating and cleaning. These examples give the impression that although such routine activities are likely initiated in the center of the attention (i.e. one intentionally starts to iron), they regularly shift between the center (when laying down clothes) and periphery (when using the iron) during the course of the activity. Meanwhile, other activities that are done simultaneously, e.g. watching TV, may also shift between center and periphery of the attention. Since only one activity can be in the center of the attention at a time, ironing will be in the periphery when watching TV is in the center of the attention.

In addition, we saw that main activities may require little attention because they are done for *resting or relaxing* purposes, in which case the majority of quotes (16 out of 21) described sensorial or cognitive activities. For example "watching a dull soap on TV hardly requires attention, it is a moment of relaxation for me". Another participant mentioned "just browsing through a magazine or brochure without actually reading it is something that hardly requires attention. However, I do it often when I come home after work. At that moment I am tired and just want to do something relaxing before I start cooking".

All main activities we found seem to frequently shift between the center and periphery of the attention. However, given the kinds of activities described (cleaning, cooking, having a shower, watching TV) it seems likely that these main activities are usually initiated in the center of the attention. See Fig. 5A for an illustration of the way main activities may shift between center and periphery of the attention.

5.2.2. Temporary side activities, internally triggered

Apart from previously discussed main activities, we also found various examples of activities that require little or no attention and can be performed as side activities during another main activity. Most these examples we found were *temporary side activities* that are quickly finished. Furthermore, the majority of these activities were *internally triggered*, meaning that they were initiated cognitively and that no sensorial stimuli clearly preceded the activity. In this cluster, we found 112 out of 285 quotes, 64 of which described bodily activities performed with the hands.

During one of the discussion sessions, the participants were talking about the side activities they perform during their breakfast ritual. Several (bodily) temporary side activities were mentioned such as "letting the cats outside", "opening the curtains" and "putting things in my bag". Apparently, several such temporary side activities are *not directly related to the main activity*, but have a *clear goal*. In one of the discussion sessions, a participant said "I got my ears pierced 2 years ago and in the beginning I was afraid that I would lose my earring. I frequently feel with my fingers if they are still in. I do this much more often than needed". Another participant mentioned "I recognize that, what I very often do is check if my zipper is not down. I certainly so this multiple times per day. I don't know why but probably to avoid embarrassing moments". The latter two examples also indicate *temporary side activities* that are *not directly related to the main activity* and that were first performed to reach a certain goal which seemed very relevant for the participant (checking earrings or zipper). However, it seems that after a while these activities are performed more often than necessary to reach the goal.

In the scenario exercise of the discussion phase, participants were asked to describe an everyday activity and write down what other activities they perform during this activity. In this exercise,

many participants wrote down activities that were *related to the main activity* and also had a *clear goal*. For example "cleaning the mirror while shaving" or "pouring out drinks during dinner". When discussing the scenario exercise in the group, one participant said "when I am cooking, I often stir the sauce or turn the meat much more often than needed. I do these things as a routine and often I forget if and when I had done it". Another participant mentioned "While cooking, I always wash my hands multiple times. Sometimes I have already forgotten if I already washed my hands and do it again". Again we see here that some temporary activities are performed more often than needed, as they seem a result of a habit, routine or ritual.

Apart from temporary activities that have (or started with) a clear goal, we also found temporary side activities that had *no clear goal*. For example "when I am reading something and taking notes, I often play with my pen. This does not really serve a goal, I just do it because I have nothing to do with my hands". Another participant mentioned "I very often play with my hair. This is not meant to straighten my haircut or anything, it is just a habit".

Regardless of the goal of temporary side activities that are internally triggered, all these activities are short. The fact that we found several examples where participants had forgotten if they already performed the activity or not indicates that once practiced the entire activity may take place in the periphery of the attention. However, such activities can of course also be focused on in the center of the attention when desired, see Fig. 5B.

5.2.3. Temporary side activities, externally triggered

Apart from the previously mentioned temporary side activities, which were all initiated as a result of a cognitive process, we also found examples of such activities that were *externally triggered*. In other words, these activities were performed as a result of perceiving a certain sensorial stimulus. We found 38 quotes in this cluster, 34 of which described bodily activities performed with the hands.

One participant described in her scenario: "I am cleaning the kitchen and I suddenly see that my breadbox is still in my bag, so I quickly take it out and put it in the dishwasher". Another example: "While putting my daughter in the bath, I put the cap on the tube of toothpaste, I saw it was off". These (bodily) activities are no routines or rituals, but short and simple actions as a direct response to a perception. Most examples were directly or indirectly related to the main activity. This could potentially indicate that external triggers could be more likely to be noticed when they relate to the main activity. For example when cleaning, one may more easily notice other things that have to be cleaned.

Similar to temporary side activities that are internally triggered, all examples of those that were externally triggered were short activities. Even though they do not seem the result of a routine, it seems as though these activities may entirely take place in the periphery, while of course one may also focus on it in the center of the attention, see Fig. 5B.

5.2.4. Ongoing side activities

Other than temporary side activities that last only a short period of time, we also found several examples of ongoing side activities, which are performed over a longer period of time during a different main activity. We found 23 examples of such activities, of which only 6 were bodily activities; the majority of quotes described sensorial and cognitive activities. For example, several participants mentioned that they listen to music or the radio while cooking. In such a situation, the activity of listening will likely regularly shift between the center and periphery of the attention. For example one might consciously listen to the music at some moments while one may focus their attention on cooking at other moments.

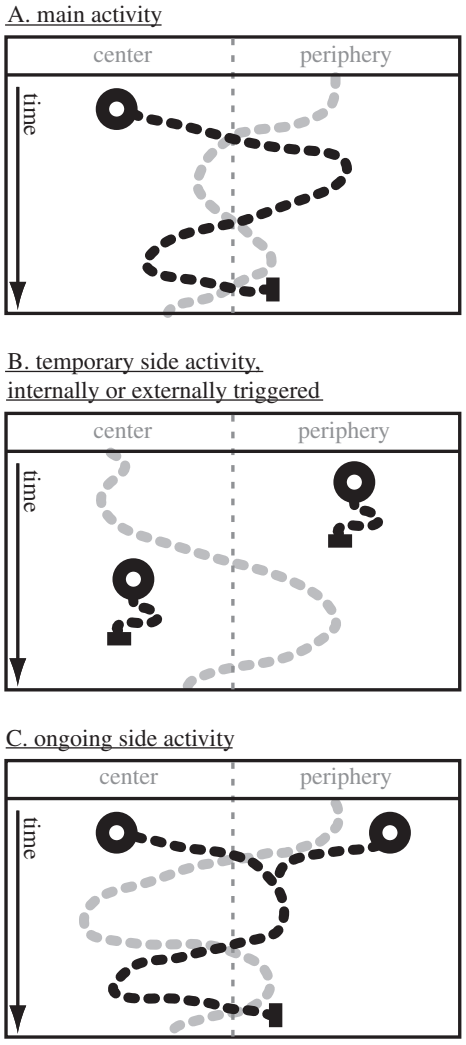

Fig. 5. Illustration of the different kinds of peripheral activities. For each kind of peripheral activity; the way the activity may shift between the center and periphery of the attention. The described activity is indicated in black while a second activity is illustrated in grey. The start of the activity is indicated by a circle and the end by a short line. For example, a main activity may shift between the center and the periphery of the attention, while activity will always be initiated in the center of the attention. Temporary and ongoing side activities may on the other hand be initiated either in the center or periphery of the attention.

This cluster seems to include activities that are not a result of a routine, rather they can be performed with varying number of resources and therefore easily shift between the center and periphery of the attention. Ongoing side activities may be started in the center of the attention, for example when intentionally turning on the radio. However such activities can likely also start in the periphery of the attention, such as when the radio has been turned on by another person, see Fig. 5C.

6. Discussion

The research described in this paper was aimed at gaining a better understanding of how the periphery of the attention is used in everyday situations. We were particularly interested in activities that people can do in the periphery of their attention. This knowledge is needed to inform the design of interactive systems that can potentially be interacted with in the periphery, while these interactions may also shift to the center of the attention when desired. We will now discuss our current understanding of everyday

peripheral activities, as well as the implications our research has for the design of peripheral interactive systems. However, we will first address the methodology we used in this study.

6.1. Methodology

The study presented in this paper involved a sensitizing phase, meant to enable the participants to reflect upon and become more aware of the activities they perform in the periphery of their attention. In the discussion phase of our study, several participants made comments such as "When looking back at the video I took during one of the exercises at home, I noticed that I very often touch my hair, I did not realize this before", or "when I made the exercises at home, I started to realize more and more how often I look at the clock or wash my hands". As a result of these kinds of remarks, we have a strong impression that the sensitizing phase effectively helped the participants in becoming more aware of the periphery of their attention, which enabled them to better discuss it in the discussion session.

6.2. The hands and the everyday periphery of the attention

In both the sensitizing and discussion phase of our study, we asked our participants to name activities that require minimum attention or that can be performed alongside other activities. A large majority of the examples we found described bodily activities (204 out of 285 quotes), most of which were actions with the hands (167 out of 204 quotes), see Table 2. We did not specifically ask the participants to name bodily activities, but asked about activities in general. However, the wording of our questions may have been of influence here; when asked to name *activities*, people may naturally first think of bodily activities that involve physical actions (e.g. preparing dinner), rather than of cognitive activities that mainly involve thought processes (e.g. daydreaming). However, it seems that sensorial activities such as watching TV or listening to the radio, as well as cognitive activities such as reading or having a conversation are clearly seen as 'activities' as well since these examples were mentioned by our participants in response to some of the first questions we asked them. Given the fact that over 50% of the found examples described bodily activities performed with the hands, our results indicate that the hands play a major role in the everyday periphery of the attention.

Although the majority of activities we found involved the hands, the two clusters 'main activities – resting or relaxing' and 'ongoing side activities', which described activities of a longer duration such as listening to music, or chatting with one's partner, included mostly sensorial and cognitive activities. Especially in case of ongoing side activities, this may be related to Multiple Resource Theory (Wickens and McCarley, 2008). These ongoing side activities are usually performed alongside (bodily) main activities such as cooking or eating, making it physically impractical to perform other bodily activities of a long duration simultaneously.

Our findings also seem related to Heidegger's (1996) notion of tools being either 'ready-to-hand' or 'present-at-hand'. Artifacts or tools are *ready-to-hand* when they are used to accomplish a task; the user focuses on the task rather than on the artifact itself. For example when using a hammer, ones focus will be on the act of hammering rather than on the hammer. In a sense, the hammer becomes an extension of the arm. Artifacts are *present-at-hand* when the user focuses on the artifact itself, such as when one sees a hammer for the first time and is figuring out its purpose. When an artifact or tool is used for an everyday activity, this tool will therefore usually be ready-to-hand. Since no attention is then needed for the artifact, this may enable the activity with the artifact to take place in the periphery of the attention. In fact, performing an activity in the periphery means that neither the artifact nor the activity will be the main focus of the user's attention. Readiness-to-hand therefore almost seems to be a prerequisite for an activity with an artifact to take place in the periphery of the attention.

6.3. Our findings in the light of attention theory

The research presented in this paper is founded in the theory of divided attention. The findings presented in Table 2, also seem largely in line with this theory. Divided attention theory for example describes automaticity (Wickens and McCarley, 2008; Wickens and Hollands, 2000) as one of the factors enabling activities to be performed simultaneously. In our data, we found numerous examples of routine activities which are likely (partially) automated, for example ironing, cooking or cleaning, but also opening the curtains in the morning or switching on the lights. Additionally we found several examples of habitual activities which participants performed much more often than needed, such as washing their hands and checking their earrings or zippers. These internally triggered activities seem automatically performed, sometimes without being fully aware of it. This may be a result of the *supervisory attentional system* (Shallice and Burgess, 1993), a cognitive mechanism that increases the likelihood that certain action or thought processes are executed. Since the goals of these activities seem highly relevant to the person (e.g. hygiene, not losing earrings, preventing embarrassment) their likelihood of being performed may be higher than other activities.

Although the research we present is founded in psychological theories of attention, our study is not focused on verifying a hypothesis about the psychological mechanisms underlying peripheral activities. Rather our aim was to gain insight in the everyday execution and implications of such activities in order to inform design. By providing an overview of everyday activities that people perform in the periphery of the attention, we wanted to contribute to a bridge between the relevant and insightful work performed in the area of psychology and the more applied work performed in the area of design research.

6.4. Designing for the everyday periphery of the attention

Several researchers and designers have taken Weiser and Brown's (1997) vision of calm technology as a starting point for developing new systems and interfaces. Most of these designs aim at presenting information that people can potentially *perceive* in the periphery of their attention (e.g. Mynatt et al., 1998; Eggen and van Mensvoort, 2009; Ishii et al., 1998; Matthews et al., 2004). In the study presented in this paper however, we have seen that in everyday life, not only perceptions engage the periphery of the attention, but so do meaningful and goal-oriented physical actions. Although only few calm technology designs are known that can be *manipulated* peripherally (e.g. Hudson et al., 2010; Edge and Blackwell, 2009), we think that this direction can broaden the scope of calm technology designs, by going beyond displaying information only. This would mean that much more kinds of interactions with technology could be designed to shift between center and periphery of the attention, and thereby fit into daily lives the way the everyday activities described in this paper fit into it. With computing technology becoming more pervasive in both our professional and private lives, we see this as a valuable direction. In this section we will elaborate on what we have learned regarding the design of interactions that may take place in the periphery of the attention, as well as present two conceptual designs that are based on our findings to illustrate how this research can potentially be translated to design.

As seen in Fig. 5, the process of activities shifting between center and periphery of the attention is highly dynamic; an activity can be in the center at one moment, in the periphery a few seconds

later and back in the center in the next moment. In the meanwhile, a second activity either started in the center of the attention or moved there from the periphery. As already evident from Weiser and Brown's (1997) statement that calm technology can engage both the center and periphery of the attention, physical interactions designed 'for the periphery' will at moments also be focused on in the center of the attention. Furthermore, when an artifact is indeed manipulated in the periphery of the attention, another activity will be taking place in the center, which has to be taken into account when designing such an artifact. In other words, when designing for the periphery, one is also designing for the center. This could even be taken a step further. Most interaction with computing technology is designed to take place in the center of the attention. Fig. 5 shows that during such interaction, other activities may be ongoing in the periphery of the attention. As this may affect the things happening in the center of the attention, designers of interactions that are to take place in the center, may take into account the things happening in the periphery. Therefore, it could even be stated that when designing for the center, one is also designing for the periphery.

A large majority of the everyday activities we found were bodily activities. We particularly found many examples of activities performed with the hands, which seems in line with Heidegger's (1996) notion of tools or artifacts being ready-to-hand. Based on these results, we see embodied interaction (Dourish, 2001) as a valuable approach to design of peripheral interactions. Dourish (2001) describes embodiment as "being grounded in and emerging out of everyday, mundane experience" (Dourish, 2001, p. 125), which seems to match the approach that we have taking in this paper. Furthermore, using technology-enhanced physical artifacts to manipulate the digital world in a broad sense seem equivalent to the way physical artifacts and tools are used in everyday life. We therefore see tangible interaction (Ullmer and Ishii, 2000; Hornecker and Buur, 2006; Mazalek and van den Hoven, 2009) more concretely as a valuable interaction style for our purpose.

As a result of the study presented in this paper, we have identified four different clusters of activities that may take place in the periphery of the attention, see Table 2. As evident from Fig. 5, the activities in these clusters differ in duration, but also in circumstances in which they are initiated (either in the periphery or center of the attention, or triggered internally or externally). The overview of these clusters presents an interesting starting point for the design of peripheral interactions, by providing different directions of such designs. When aiming to design physical interactions with technology that are to be performed in the periphery of the attention, we saw most potential in the clusters describing temporary side activities which are triggered internally or eternally. The ongoing side activities we found were mostly sensorial or cognitive activities, which could be more interesting as inspiration for the design of peripheral information displays, rather than physical peripheral interactions. Since the everyday main activities we found were mostly household or hygiene activities, they seem difficult to translate to interactions with technology. We now present two preliminary concepts of peripheral interaction design, both inspired by the clusters describing temporary side activities. These concepts are meant to illustrate the design implications of our findings, rather than to present finished concepts.

6.4.1. In one's pocket

A suitable application for peripheral interaction would be to look up information on a mobile device; an activity that many people seem to frequently perform, but which requires focused attention to read the information on the screen. For example checking for messages or looking at one's agenda. One way to turn this into a potentially peripheral activity would be to allow the user to request the information through a simple but specific gesture on the mobile device, such as pressing on it with three fingers. This gesture can be performed while the device is in the user's pocket. In reaction to this gesture, the device could provide information on the number of messages through a vibrating signal; the longer the signal, the higher the amount of messages. This could even be more specified by indicating types of messages (e.g. email, instant messaging, voice-mail) through different intensities of vibrations. Although this will require some learning, it seems likely that a user will quickly be able to understand the approximate number of messages, even without focusing the attention on it. This could be seen as a *temporary side activity* that is *internally triggered*, which may be performed peripherally to gain overall awareness of the number of messages.

6.4.2. Teacher tool

Another possible application of peripheral interaction could aim at memorizing certain events or tasks that one needs to perform in the near future. This could be relevant for specific target groups, such as primary school teachers who need to attend to different students. While helping one student, a teacher may observe another student that needs additional explanation, deserves a compliment or must be stimulated to perform a certain task. Normally the teacher would need to write this down to avoid forgetting it, which requires focused attention and distracts from the current main task. This could potentially be improved through peripheral interaction on a wearable device. Imagine that when an event is observed that needs to be memorized, the teacher just subtly points at the student in question and squeezes his or her hand. The name of the selected student is then stored on the teacher's computer together with a time stamp, so that the teacher can later see which students she still has to attend to. This would lower the amount of mental resources required and the activity of storing the students names may potentially shift to the periphery of the attention. This would be an example of a *temporary side activity* which is *externally triggered* by the observation of an event that needs to be memorized.

6.5. Ubiquitous computing and peripheral interactions

The idea of calm technology is grounded in Weiser's (1991) formulated vision on ubiquitous computing. Although this vision has been widely adopted, it has also been critically discussed. Rogers (2006) for example, doubts the technical feasibility of ubiquitous technologies proposed by Weiser, since despite the efforts of ubiquitous computing researchers, "their achievements are limited by the extent to which they have been able to program computers to act on behalf of humans" (Rogers, 2006, p. 418). Bell and Dourish (2007) on the other hand, argue that ubiquitous computing should no longer be viewed as a vision for the future, since it is already here. However, "rather than being invisible or unobtrusive, ubicomp devices are highly present, visible, and branded" (Bell and Dourish, 2007, p. 412). Interestingly, both these statements seem to view the area of ubiquitous computing from a perspective of technological developments, by discussing the extent to which Weiser's vision (Weiser, 1991) have been achieved in terms of the required technologies.

Whether or not Weiser's idea of ubiquitous computing is or will be achieved in terms of technology, however, we observe that in terms of 'calmness', modern technologies are nowhere near what Weiser envisioned. Nevertheless, given the rapid increase in usage of (mobile) computational devices, we think that Weiser's observation that computing technology will be increasingly ubiquitous in everyday life did indeed happen. In fact, we think that the role of such technologies will only keep increasing. We therefore argue that to fit these technologies into everyday life, Weiser's aim to make the interaction with these technologies shift to the periphery

of the attention is still highly valid. By laying out that peripheral activities frequently take place in the everyday physical world, we have shown that the way of interacting proposed by Weiser already seems to take place in non-technological settings. We therefore believe that whether or not technological developments have already (or will ever have) reached the level that Weiser envisioned, the interaction style proposed in his vision will be feasible with technology of any level of sophistication.

7. Conclusions

In this paper, we have described a qualitative study aimed at gaining an understanding of the kinds of everyday activities that can be performed in the periphery of the attention. This knowledge was gathered to inform the design of 'peripheral interactions'; interactive systems that can be manipulated with minimum or no attention.

As a result of our study, we have seen that the majority of everyday peripheral activities are performed with the hands. Our data therefore indicate that tangible interaction (Ullmer and Ishii, 2000; Hornecker and Buur, 2006; Mazalek and van den Hoven, 2009) seems a suitable interaction style for our purpose. In addition, we have identified four different clusters of peripheral activities. These clusters are in line with theory suggesting that activities that are automated usually required a low amount of mental resources. Furthermore, we found that activities are more likely to be performed in the periphery of the attention when they are personally highly relevant, as a result of the supervisory attentional system or priming.

The work presented in this paper is founded in Weiser and Brown's (1997) vision of calm technology. Several researchers have designed and studied systems inspired by this vision. Most of these examples aim at presenting information that is to be *perceived* in the periphery of the attention. However, since we observe that everyday physical activities are frequently performed without paying much attention to them, we find it remarkable that only few studies are known that aim at creating physical interfaces that can be *manipulated* in the periphery of the attention. By studying and clustering everyday peripheral activities, we believe to have laid a basis for further research and design work in this area.

Acknowledgements

We thank the participants for investing their time in performing our (pilot-) exercises and taking part in sessions. We also thank the coders for their help in clustering and discussing the results.

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