Exploring Peripheral Interaction Design for Primary School Teachers

Saskia Bakker, Elise van den Hoven, Berry Eggen, Kees Overbeeke†
Department of Industrial Design, Eindhoven University of Technology, the Netherlands
{s.bakker; e.v.d.hoven; j.h.eggen}@tue.nl

ABSTRACT
This paper explores the concept of peripheral interactions; interactions with technology that take place in the background or periphery of the attention. We present two designs for a classroom setting. CawClock makes selected time frames audible in order to provide teachers with awareness of time. NoteLet is designed to support the teacher in observing children's behavior, by enabling him or her to take pictures of the classroom through straightforward interactions on a bracelet. A qualitative, two-week exploration of both systems in a classroom revealed that the soundscapes of CawClock indeed shifted to the periphery of the attention and supported the teacher's time awareness. The actions with NoteLet did not shift to the periphery. However, the tangible aspects of NoteLet seemed to facilitate the interaction to be quick and simple, which may indicate that it could shift to the periphery with more practice. Tangible interaction therefore seems a promising interaction style for this purpose.

Author Keywords
Peripheral Interaction, Awareness, Attention, Periphery, Tangible Interaction, Design, Calm Technology, Audio.

ACM Classification Keywords
H5.2. Information interfaces and presentation: Auditory (non-speech) fee dback, Interaction styles, Prototyping Theory and methods, User-centered design.

General Terms
Design, Experimentation.

INTRODUCTION
Computing technology has become widely accepted in the everyday world and is being integrated in all kinds of artifacts and environments. These developments have led to broad discussions on how digital technologies can fit into everyday life. Several areas of research (e.g. Embodied Interaction [3] and Tangible User Interfaces (TUIs) [19]) have looked for inspiration in human interaction with the physical world, when developing new interactions with the digital world. Weiser and Brown [20] envisioned *calm technology*, which "engages both the center and periphery of the attention and in fact moves back and forth between the two" [20, p. 74]. This vision is founded in the observation that many interactions in the physical world take place without focused attention. For example, we do not have to consciously look out the window to know what the weather is like, or consciously move a cup to our mouth to drink. Human perceptual and motor abilities, supervised by the attention system, enable these actions to take place in the background or *periphery* of the attention and only shift to the *center* of the attention when relevant or desired. Traditional methods of human computer interaction (e.g. screens, keyboards) typically require focused attention. With technology becoming ubiquitously present in everyday life however, it will no longer be possible nor desired for all technology to be in the center of the attention, also see [20].

In line with the vision of calm technology [20], we believe that leveraging human attention abilities in interaction design will support computing technology to better fit into everyday life. This may enable users to interact with technology in the periphery of their attention while this interaction may also shift to the center when relevant. We call these types of interactions *peripheral interactions*.

Previous research on attention in everyday life revealed that awareness of information present in the periphery is often gained through auditory perception [2]. Furthermore, many actions that require little or no attention seem to involve physical tools or artifacts [1]. We therefore expect that peripheral interactions with technology will benefit from using tangibles for interaction and/or audio to convey information.

This paper explores the design and evaluation of peripheral interactions. We have developed two interactive systems; CawClock and NoteLet. Both systems are designed to be used by teachers of the first grades of primary school. CawClock is designed to provide peripheral time awareness by using subtle soundscapes to indicate the time passing through a selected timeframe. NoteLet allows teachers to mark moments which they want to remember later on, by taking a photo. This is done through a straightforward interaction on a bracelet that can potentially be performed peripherally. To evaluate the potential of these systems with respect to peripheral interaction, we placed prototypes of both systems in separate classrooms for two weeks. In this paper, we

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describe the design and evaluation of these systems as well as our findings regarding peripheral interactions in general.

THE PERIPHERY OF THE ATTENTION

Before we present our peripheral interaction designs, we will first discuss theoretical background on human attention processes and lay out our understanding of the periphery of the attention.

In any situation, there are multiple activities available that one can undertake. Since we cannot perform all these activities at once, a choice has to be made. Models describing the human attention process (models of *divided attention* [12, 21]) therefore center around a number of potential activities that one can perform as a result of sensorial or intellectual information input. These activities may be bodily (e.g. running), cognitive (e.g. thinking) or sensorial activities (e.g. listening to music). Divided attention theory [12, 21] describes attention as a finite amount of mental resources that can be divided over one or more of these activities. Activities will thus only be performed when resources are allocated to them. Figure 1 gives an illustrative overview of divided attention theory, in which potential activities are indicated as vertical bars, and mental resources as white circles.

The amount of mental resources needed for an activity depends on the required mental effort, illustrated as the length of bars in Figure 1. Activities that one is very experienced in (*automated processes* [21]), such as walking, require only few mental resources and can, to some extent, be performed simultaneously with other activities. Furthermore, certain activities are more likely to be performed than others as they are more relevant in the current situation. For example, when you hear your own name in a distant conversation, this is likely to attract your attention, as a result of a cognitive process called *priming* [18]. Similarly, bodily or cognitive activities can have a higher likelihood of being performed, which is managed by the *supervisory attentional system* [17]. The likelihood of an activity being performed is represented in Figure 1 by the brightness of bars; the darker the bar, the more likely the activity is to be performed.

The word periphery is often used in the context of visual perception, to indicate the parts of vision away from the focus of the visual field [21]. However, in the field of ubiquitous computing, the periphery is usually seen broader, describing "what we are attuned to without attending to explicitly" [20, p. 79]. In line with theory of divided attention, we describe the center of the attention as the one activity to which most mental resources are currently allocated. The periphery consists of all other potential activities, regardless of whether mental resources are allocated to them or not, see Figure 1.

RELATED DESIGN AND RESEARCH

In our research, we explore interactions that take place in the periphery of people's attention. These *peripheral interactions* can consist of sensorial actions such as hearing sound as well as bodily actions such as manipulating an artifact.

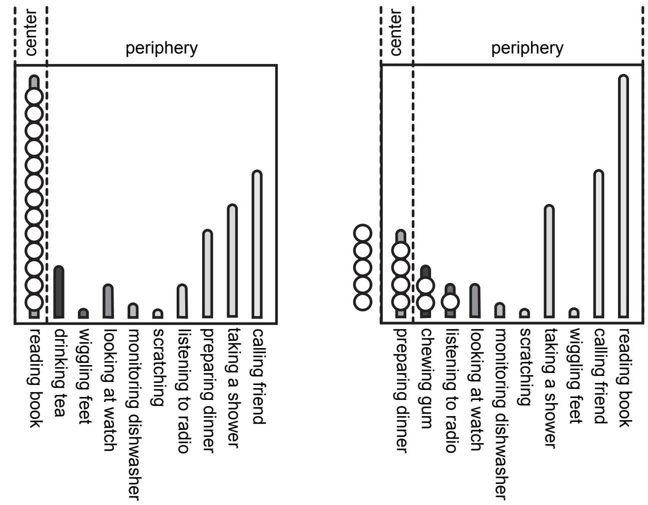

Figure 1. Illustration of the center and periphery of the attention: division of resources during a high attentional task (left) and a combination of low attentional tasks (right). Vertical bars represent potential activities that are performed when resources (white circles) are allocated to them.

Several related studies have aimed at employing the periphery of the attention. Most of this work explores displaying information to facilitate awareness. *Ambient Information Systems* [15] for example, display non-crucial information and can move between periphery and focus of the attention. Motion Monitor [13] is referred to as a *peripheral display* that uses colored light to provide awareness of movements at remote locations. The Dangling String [20] represents the network activity in an Ethernet cable by rotating a physical string. This creates a visual and auditory display to inform office workers. AmbientROOM [11] explores background monitoring of information such as the activity of fellow workers, displayed through light and sound. Home radio [5] makes utility streams audible to support awareness of and connectedness to the home while away.

Although most related research focuses on perceiving information in the periphery of the attention, some examples are designed for physical peripheral interaction. Edge and Blackwell [4] present *Peripheral Tangible Interaction*; digitally-augmented physical tokens that can be manipulated outside the visual focus, to track or update task progress. "Whack Gestures" [9] is an interaction style that requires minimal attention, for example firmly striking a mobile device to quickly react to a cue while the device is still in the user's pocket. Hausen and Butz [6] present a prototype that projects information about the user's agenda on his or her desk to facilitate peripheral awareness. Furthermore, the user can interact with this information (e.g. postpone an agenda item) through wiping gestures which may be performed peripherally.

PERIPHERAL INTERACTION DESIGNS

Most related examples of peripheral interactions were designed for offices, which has proven to be a valuable target context since many relevant information streams are present.

To extend the application area of peripheral interactions however, we are interested in exploring contexts in which the computer currently plays a less salient role.

We have focused our current study on teachers of the first grades of Dutch primary schools, who teach classes of 25 to 30 children of four to six years old. The first grades of primary school in the Netherlands are similar to what in other countries is known as preschool or kindergarten. Since the authors are design-researchers with no practical experience in classroom contexts, two interviews with teachers and observations in a classroom were conducted to get a better understanding of the teacher's work and environment. This taught us that next to activities such as group talks, reading to the children and playing outdoors, a typical school day centers around the 'working lessons'. During a working lesson, which takes place twice a day, the children perform individual and group tasks such as role play, painting, language exercises and construction play. The teacher's work during a lesson consists of several tasks such as giving instructions, observing children's development, answering questions and stimulating learning. To perform this work, the teacher usually walks around the classroom, sits down with a child or stands on the side of the room to observe.

Several educational Tangible User Interfaces exist [14], most of which aim at supporting children's learning in abstract domains (e.g. [16, 22]). In the classrooms we visited, a lot of physical artifacts were already used, such as a necklace to indicate that the teacher cannot be disturbed or magnets with which children can choose activities. As physical artifacts already play an important role in the everyday routine in a classroom, we believe that TUI applications may easily fit in.

After having obtained an understanding of the everyday routine in primary school classrooms, a creative brainstorm session about peripheral interactions for this context was held among the authors. Two designs were selected for further development; CawClock, which focuses on the perception of information in the periphery of the attention, and NoteLet, which explores physical actions performed in the periphery.

CawClock

In the classrooms we visited, we saw that fixed routines are important during working lessons. Every lesson starts with 15 to 20 minutes of independent work; the children have to work on a single task and cannot ask the teacher for help. During the remaining 30 minutes, the children are allowed to choose a different task and may ask for help. At the end, 10 minutes are used for cleaning up. Since not all children know how to read the clock, or even have an understanding of how long 15 minutes are, the teacher uses expressions such a 'when the big hand is at the three, you can choose another task'. She frequently looks at the clock and reminds the children of the remaining time. This helps the teacher structure her time (e.g. all children need to be observed during independent work), but it also reminds the children of the current 'rules' and remaining time.

To support time awareness, we developed CawClock, see Figure 2. CawClock consists of a display that shows the time as a regular analog clock, and four tangible tokens, each with their own color and image of an animal on it (a cat, bird, frog or owl). The tokens can be used to mark a time-frame on the clock. For example, if at 10.30h the children must work independently until 10.45h, the teacher can place a token next to the 9 of the clock, where the big hand will be at 10.45h. The part of the clock between the 6 and the 9 (the current time and the end of the time-frame) will then be colored. While the big hand is inside the colored part of the clock, a background soundscape will be heard that corresponds to the animal on the token (i.e. cat-sounds, bird-sounds, frog-sounds or owl-sounds). Furthermore, the soundscape gradually changes; the number of animals heard increases toward the end of the timeframe, without increasing the volume of the audio. This way, the soundscape informs the teacher and children that the time-frame is ongoing, as well as how much time has approximately passed already.

The colored parts of CawClock are similar to those used in other educational time-keeping materials. The ColourClock [23] for example is a mechanical clock with fixed colored parts and one hand. Different from the ColourClock, CawClock has two hands, allowing it to be used as a regular analog clock. Moreover, the audio is designed to provide peripheral awareness of marked timeframes. The visual aspect of CawClock is not meant to be perceived in the periphery but can be used when detailed information is required. The tangible interaction used to mark time frames is designed to be in the center of the attention; the teacher will consciously mark a timeframe and explain this to the children. The peripheral interaction intended with CawClock consist of the perception of soundscapes that represent timeframes.

To enable evaluation, we developed a fully functioning prototype of the CawClock, see Figure 3 and [24] for a video.

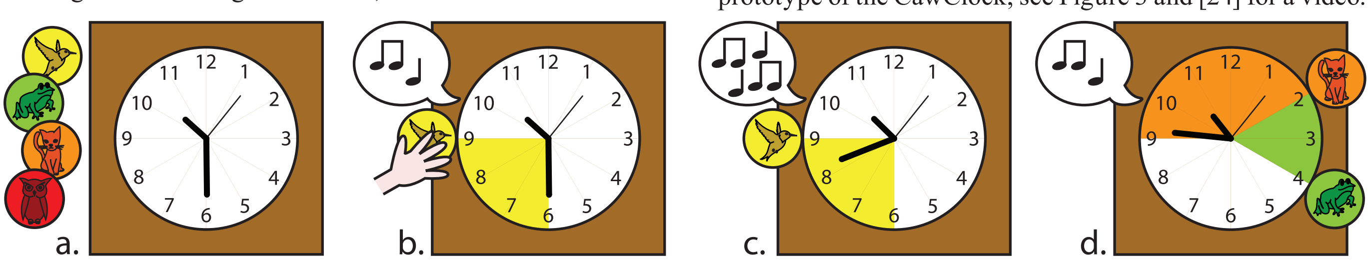

Figure 2. Illustration of the CawClock; a clock with 4 tokens (a), a marked timeframe is represented by color and a soundscape of animal sounds (b), more animals are heard toward the end of the timeframe (c), multiple timeframes can succeed each other (d).

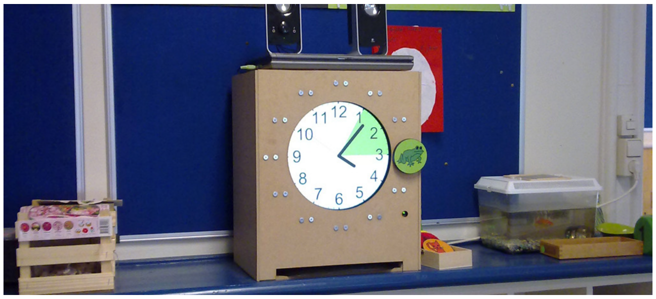

Figure 3. CawClock prototype in classroom.

This prototype used a TFT-screen and conductive magnetic connections to attach the tokens to the clock.

NoteLet

Among the many tasks of a teacher, an important one is to observe the children's abilities. This way, the teacher keeps track of the children's development over time, in areas such as motor skills, social skills and language. Observations are either done intentionally (the teacher sits down, observes particular children and particular behavior), or unintentionally (the teacher is performing another task but sees a child perform behavior that is worth making a note of). Examples of unintentional observations are seeing a child holding the pencil in a wrong way, or hearing a child read a sentence. In case of unintentional observations, the teacher can walk to the desk to make a note or remember to make a note later. At the end of every few days, the teacher enters the notes into a digital system. As there is not much time for intentional observations, unintentional observations play an important role in keeping track of development. These observations however, may distract the teacher from her current activity when a note needs to be made. On the other hand, remembering it by heart may not be sufficient.

To support unintentional observations, we have developed NoteLet, see Figure 4. This interactive system consists of a camera located in the corner of the classroom and a bracelet that the teacher can wear around the wrist. When the teacher squeezes her wrist, the camera will take a picture, which is stored with the date and time. On the back of the bracelet, the names of all children are listed (see Figure 5). When the area next to a name is touched, not only a picture, but also the child's name is stored. To make it easy to find the right name, girls are listed on the right while boys are on the left, both in alphabetical order. Furthermore, the touch-sensitive areas are overlaid with patches of fabric; smooth fabric for children in first grade and rough fabric for children in second grade. The pictures can be used at the end of every few days when entering observations in the computer.

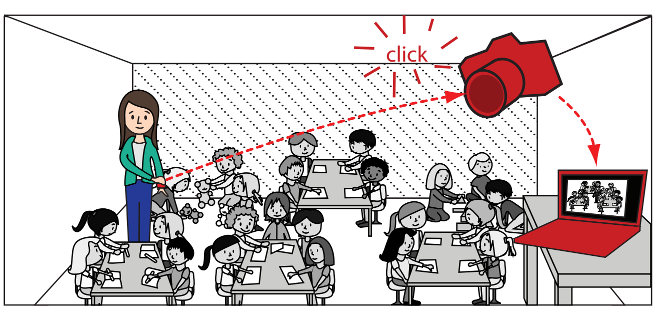

Figure 4. Illustration of NoteLet: a bracelet that can be used to take a picture of the classroom.

Taking pictures in case of unintentional but relevant observations is meant to replace the notes that are currently used. Although pictures may in some ways be less specific than notes, and do not capture everything (e.g. audio), we expect that when seeing a picture taken within the past days, a teacher will be able to recall his or her observation.

Since the system is wearable, the teacher does not have to change locations to use it. Taking pictures is intended to be a quick and straightforward action that can potentially be performed in the periphery of the attention. Taking a picture without a child's name is likely easier than selecting a name. However, the information in the picture is also less detailed. By incorporating both functionalities in our design, we hope to learn more about the value of each of these two options.

For the evaluation of this concept, we developed a working prototype, see Figure 5 and [25] for a video. The bracelet uses simple touch-buttons and a ZigBee module [26] to communicate to a computer, which is connected to a 5 mega pixel camera mounted on the ceiling of the classroom corner.

USER EXPLORATION

To learn more about the design and evaluation of peripheral interactions, we set up a user exploration with CawClock and NoteLet. As this is a first attempt to design peripheral interactions for a classroom context, we felt there was a lot to learn about the setting and goals of our designs. We therefore decided to take an explorative approach to the evaluation, rather than using a formal setup. We wanted to explore the value of our designs in the classroom setting (i.e. the purposes for which teachers may use them) as well as their suitability to blend into the everyday routine of the teacher, which is necessary for the interaction to shift to the periphery. Furthermore, we were interested in qualitatively exploring which features of our designs may or may not support the

Figure 5. NoteLet bracelet prototype: action to take a picture without (top) or with (bottom) name.

interaction in shifting to the periphery of the attention. We thereby hope to inform future peripheral interaction design. In line with these objectives, we found it important to evaluate our designs in the context of use and for a longer period of time, which is also recommended for ambient information systems [7] as well as for tangible interaction [8]. We installed each prototype in a separate classroom for two weeks. In these two weeks, the teachers used the prototypes six days. The two classrooms were selected from the same school and the explorations ran simultaneously, to encourage discussion among the teachers about the designs.

Given the intended explorative nature of the evaluation, we gave the teachers open instructions. We demonstrated the prototypes and explained how they could be used, but explicitly pointed out that the teachers could use them in any way and for any purpose they wanted. By using this approach, borrowed from the Technology Probes method [10], we hoped to learn more about the teacher's needs and desires as well as inspire future peripheral interactions for this context. We did not inform the teachers of the intention of the designs being used in the periphery of the attention; we expected that pointing to this may have the opposite effect.

To evaluate the use of our designs, we arranged an observation session in each participating classroom during a working lesson in the second week of deployment. During these 30 to 45 minute sessions, two researchers were present to take notes and a video was recorded for later analysis. At the end of the two week period, we conducted individual open interviews with each teacher as well as a group interview in which the teachers discussed their experiences among each other. To facilitate another study outside the scope of this paper, we also developed a completely digital version of the CawClock. The design was the same as the presented tangible design, only the tokens were icons on screen that could be dragged to the clock using a mouse. This digital CawClock was use by a third teacher, who also participated in the group interview. His remarks about the audio design, as well as the CawClock concept in general have been taken into account in the findings we present in this paper.

FINDINGS AND DISCUSSION OF THE DESIGNS

Using CawClock

The teacher who experienced the (tangible) CawClock, used it every working lesson (9 times during the deployment) to indicate which rules applied at which moments and for how long. For example during the first 15 minutes of the lesson, children had to work independently, while during the remaining time the children could ask questions. Furthermore, she used the CawClock twice to indicate when the children should be finished cleaning up, once to indicate the time available for lunch, and once to specify a timeframe in which they would play a game.

When marking timeframes, the teacher used the same token for the same activity every day, for example the cat to indicate independent work. The teacher mentioned that this way, the children automatically know what they are or are not allowed to do by listening to or looking at the clock. Although the teacher still announced the remaining time regularly, e.g. "look at the clock, we have 10 minutes left", she also mentioned that she felt the children came to her less often than normal to ask if they could choose another task.

CawClock and the everyday routine

During the observations, the soundscapes of CawClock seemed to fit well in the classroom context. In the 45 minute video we recorded, of the 10 children that were in sight of the camera, only three looked up at the clock when hearing a sound, each about 4 to 5 times. Furthermore a couple of children imitated the sounds, but overall the soundscapes in the classroom did not seem to interfere with the everyday routine. This was also acknowledged by the teachers.

CawClock and the periphery of the attention

Of the two teachers who used the two versions of CawClock, one indicated to be somewhat annoyed by the soundscapes. However, she also indicated that after a few days she got used to them, to a point that she did not notice that the sound had stopped. The other teacher was not annoyed by the audio and mentioned "I hear it, but I am not focused on it". During the observations, the audio also did not seem to attract the attention of the teachers much; only two instances were observed where a teacher looked at the clock when hearing a sound. This indicates that the soundscapes seem to have been in the periphery of the teacher's attention at moments.

CawClock's sound design

The teacher who used the tangible CawClock, frequently marked two successive timeframes; one for independent work and one for the rest of the lesson. She indicated that she always noticed the first timeframe ending as the cat-sounds would change to bird-sounds. In other words, the audio shifted to the center of the attention at the transition of two timeframes. She also mentioned that the end of the second timeframe was less clear, as the audio simply stopped.

We also saw the audio shifting from the periphery to the center of the attention at less relevant moments. It attracted the attention of one teacher when the sounds annoyed her. This particularly held for the cat and frog; the owl- and bird sounds were less distinct and easier to ignore. When discussing this in the group interview, we were surprised that the teachers mainly used words that are normally used for a telephone ringing, e.g. "maybe it should 'ring' less often". Although this way of thinking does not match our ideas of peripheral soundscapes, it is an understandable way of reasoning. Other commonly used devices (e.g. mobile phones or alarm clocks) use sound mainly to attract the attention. Since we deliberately did not inform the participants that our soundscapes were to be perceived peripherally, it may very well be the case that they thought they were expected to notice the sound every time it was played. This may have caused the experienced annoyance with some soundscapes In hindsight, it may therefore have been better to explain that the sounds were intended as background soundscapes.

The intention of CawClock was to provide the teachers with peripheral awareness of time, by means of background soundscapes. The audio changed as a timeframe went by; more animals were to be heard closer to the end of the timeframe. Both teachers however indicated that this gradual change was not apparent to them. The audio therefore mainly provided awareness of the fact that a timeframe was still ongoing. To know how much time was left, they needed to look at the clock. Despite this, both teachers found the audio useful since they did not have to look at the clock to know that the timeframe had not ended; they were automatically informed through the audio.

One of the teachers mentioned that glancing at the CawClock supported time awareness. When looking at a normal clock, a glance was not enough for her to realize how much time was left until the end of the lesson; she had to remember which time she agreed upon, interpret the current time and so on. The color parts of CawClock however, gave her an immediate, clear overview of the time left. She found this useful when she needed to finish a task; glancing at the CawClock helped her to know if she was on schedule or not.

Using NoteLet

The NoteLet was used in every working lesson; 9 times during the deployment. The teacher wore the bracelet during independent work (the first 15 to 20 minutes of the lesson), which is usually the moment she takes notes. At the end of independent work, she took the bracelet off. During the two weeks of the experiment, 58 pictures were taken; 6 or 7 pictures per lesson. The majority of these pictures (39 out of 58) included a specific child's name. The teacher indicated that she used the pictures with names in two different situations. First of all, she took a picture with name when a child did something she wanted to remember, such as sitting on a chair incorrectly. The second situation, in which she took pictures with name, occurred when she remembered that a child had not been working well earlier on. At such a moment she took a picture with the name of that child to check if the child worked better later in the lesson. According to her, this enabled her to have 'extra eyes'. She preferred this over turning around to look at the child, which would distract her and might be intrusive for the observed child.

The option to take a picture without a name was used in 19 out of 58 cases. The teacher indicated that she used it to learn if she was aware of everything that was happening in her class; "you think you know everything, but with this picture you can see if that is really the case".

The teacher viewed the pictures at the end of each day. She did not enter observations in the computer; this was not needed during the exploration. However she indicated that it could be useful for that purpose. Furthermore, she noted that taking 6 to 7 pictures per lesson would be too much when using NoteLet for a longer period of time; it would simply take too much time to look at all these pictures after school hours. The two other teachers who participated in the group interview also imagined that this would be a problem. Although our research interest is mainly in the manipulation of the bracelet, this is of course important to take into account. The reason we used pictures was the amount of information they can contain, e.g. location, posture, activity. However, one of the teachers who did not use the NoteLet, commented "I would have to think 'When did I take this picture? Who was it about? Where is that child in the picture?', phew, that will take too much time". The fact that pictures contain a lot of information may thus be a disadvantage and pictures may therefore not be the right medium for every observation.

NoteLet and the everyday routine

The teacher indicated that the NoteLet was rather simple to use; she could quickly squeeze her wrist and easily found the right name on the bracelet, particularly because of the alphabetical order and the different fabrics that were used. When asked if taking a picture distracted her, the teacher said "It took a few seconds, I had to look at it to find the name but I was not completely distracted from my main task". Furthermore, she mentioned "It is useful as it is at hand, I do not have to go and write it down every time I see something". Given these comments, we have the impression that using NoteLet integrated well in the routine of the teacher.

NoteLet and the periphery of the attention

During the observation, one picture was taken without a name, which required only a very brief look at the bracelet. However, the teacher consciously needed to look at the bracelet to find a name, as was also evident from the pictures taken with NoteLet (see Figure 6). The teacher mentioned "I did not know by heart where each name was, I used every name once or twice. If you use it more often, it will probably become a routine". Since conscious attention seemed needed to interact with the bracelet, it appears that it was not used peripherally during our exploration. We know [1, 12, 21] that mainly automated activities are performed in the periphery of the attention. The two weeks of our exploration were clearly not enough for the interactions with NoteLet to shift to the periphery; the teacher did not have automated knowledge of the location of the names on the bracelet. Squeezing the wrist to take a picture seemed to be a more straightforward

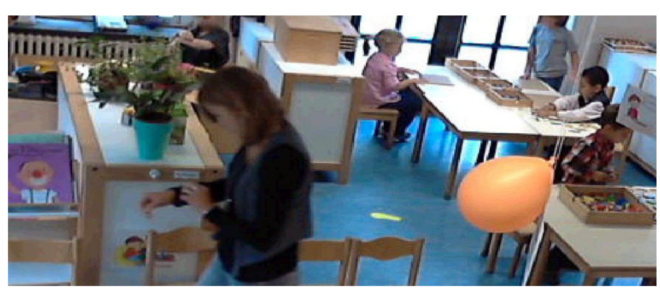

Figure 6. Picture taken with NoteLet (teacher in foreground).

interaction which may more easily shift to the periphery. However, our observations are too brief to confirm this.

NoteLet's interaction design

The design of NoteLet, which included alphabetical order of names and different fabrics to distinguish names, seemed to support the ease with which the teacher could find the right name. However, the interaction did not shift to the periphery of the attention during our exploration. This may raise the question if the activity of taking notes is suitable for peripheral interaction. Interactions with NoteLet started with (1) observing noteworthy behavior, followed by (2) finding the name on the bracelet and (3) pushing the corresponding button. The first of these three actions likely takes place in the center of the attention; the teacher consciously decides to take a note of observed behavior. Although the other two actions did not take place in the periphery during our experiment, they required only a few seconds and seemed to fit in the teacher's everyday routine. We find this a promising finding and therefore expect that with a more sophisticated design (e.g. to prevent having to select among 28 individual buttons) as well as with more time to experience the design, similar interactions may be performed peripherally.

GENERAL DISCUSSION ON PERIPHERAL INTERACTION

In this paper, we have presented two peripheral interaction designs for primary school teachers; CawClock and NoteLet. The two designs separately explore two types of peripheral interaction; the peripheral perception of (auditory) information on the one hand and physical actions performed in the periphery on the other hand.

From a previous study [2] we concluded that audio is used in everyday life to facilitate awareness of information in the periphery. During our exploration, the soundscapes of CawClock indeed shifted to the periphery of the attention at certain moments. Although particular sound designs may require improvement to make them more pleasant, with CawClock we have seen that indeed audio seems a suitable modality for peripheral (perceptual) interactions; teachers indicated that they knew whether a time-frame was still ongoing without having to look at the clock. Furthermore, the audio shifted to the center of the attention at certain relevant moments, which confirms our previous findings.

The physical actions required for NoteLet were not performed in the periphery of the attention. Two weeks deployment may not have provided the teacher with enough experience to perform the interactions peripherally. This indicates that longer term studies are needed to evaluate if and how physical interactions (such as the manipulation of NoteLet) can shift to the periphery of the attention.

In previous research [1] we saw that everyday physical objects and tools are often used in the periphery of the attention, indicating that tangible interaction may be a suitable style for peripheral interaction design. Although the NoteLet design is not a classical example of tangible interaction, the tangible aspects, such as the patches of fabric representing a child, seem to have made the interaction quick and straightforward. Particularly the fact that the design was wearable and thus at hand, seemed to facilitate the interaction to fit in the everyday routine. Although the interaction with the NoteLet prototype did not shift to the periphery of the teacher's attention, the success of the tangible aspects of our design makes it interesting for us to further explore the use of tangible interaction in the periphery of the attention.

Given the success of auditory perception as peripheral interaction as well as the potential of tangible interaction for this purpose, it would be interesting to think about combining the two. Auditory perception could potentially support tangible peripheral interaction, for example playing a short and subtle audio cue that represents a child, when going over a name on NoteLet. This could support finding names and may enable the teacher to not have to look at the bracelet. Since audio seems to shift to the periphery more easily than a physical action, such cues may support the action to shift to the periphery of the attention. Further explorations of such interaction would be required to learn more about this.

Most related work that aims at employing the periphery of the attention focuses on the office context. Based on our explorations with CawClock and NoteLet, we have experienced the classroom as a suitable environment for peripheral interactions. Although computing technology has a lot of potential to support the teacher's tasks and activities, this is currently barely applied since it is not easily accessible (e.g. the teacher is not sitting behind a computer and needs to keep her eyes on the children). What we find particularly interesting about this context is that even though the main user frequently walks around, she stays within a confined space (the classroom). This opens up opportunities to integrate tangibles and other parts of a design into this environment, without having to confine it to a specific location such as a desk. We can for example imagine different tangibles or ambient information systems 'lying around' the room, available to be interacted with when desired. Such interactions will not only be suitable for classrooms, but can be generalized to similar situations in which a user walks around in a predefined space, such as a waiter in a restaurant or a nurse in a hospital.

CONCLUSIONS

In this paper we presented the implementation and user exploration of two peripheral interaction designs developed for primary school teachers. CawClock aimed at providing peripheral awareness of time through background soundscapes, while NoteLet enabled to photograph moments that the teacher wanted to make a note of, through a simple and straightforward interaction on a bracelet. A two-week, qualitative user exploration aimed at evaluating the value of these designs as well as their ability to blend into the everyday routine. CawClock showed to be valuable to monitor time as well as current 'rules' in the classroom. NoteLet was used to remember moments as well as to have 'extra eyes' on the children, although looking at the pictures after school appeared to be too time-consuming. Both systems seemed to fit well in the classroom context. We furthermore found that the auditory perception of CawClock indeed shifted to the periphery of the attention at certain moments; the teachers heard the audio but did not have to focus their attention on it. The interactions needed for NoteLet did not shift to the periphery; two weeks appeared not enough to make this happen. The tangible aspects of the NoteLet supported the interaction to be quick and straightforward as well as at hand. Tangible interaction thus seems a promising interaction style to further explore in peripheral interaction design. Our future work will therefore consist of further exploring peripheral interactions in classroom settings by using tangible artifacts in combination with background auditory feedback.

This study adds to the work on calm technology [20] by presenting innovative peripheral interactions. These provide new insights in the design choices that may contribute to peripheral interaction as well as the kinds of applications and goals such interactions are valuable for. For example, the relatively unexplored application area of the classroom seemed relevant for peripheral interactions.

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