Sounds Like Home: Sonification and Physical Interaction in the Periphery and Center of the Attention

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ABSTRACT

Our auditory perception skills enable us to selectively place one auditory channel in the center of our attention and simultaneously monitor others in the periphery of our attention. In this paper, we present and discuss two design cases that explore the design of physical interactive systems that leverage this perception skill to unobtrusively communicate relevant information. Sounds are mechanically generated by these systems, which strengthens the coupling between sonification and physical interface. Both resulting designs are aimed to be used in a home environment.

1. INTRODUCTION

Sound is used in many interactive systems, mainly for alerts, status indication, data exploration, and entertainment [9]. Such *sonifications* aim at representing information using non-speech audio. More specifically, the area of *interactive sonification* [4] focuses on using sound during interaction with computing systems, e.g. to provide information about data under investigation, or to support interaction. This is typically implemented when users need to visually focus on something else, or when immediate action is required. These sounds are therefore mostly designed to be in the center of the listener's attention.

Different from visual objects, sound is always perceivable. We cannot 'avoid' auditory channels like we can 'avoid' visual channels by simply not looking at them [5]. An interesting aspect of sound however, is that we are able to selectively place one auditory channel in the center of our attention and monitor others in the periphery of our attention. This cognitive phenomenon, also known as the "cocktail party effect" [1], is frequently used in everyday life. For example, when driving a car, one will normally focus the attention on the road, the radio, or the conversation with passengers. However, when the engine suddenly makes an unusual noise, the attention immediately switches to this sound. In other words, the sound of the engine that is normally in the periphery of the attention shifts to the foreground. Similarly, all kinds of information, such as the weather, activities of colleagues, a conversation of people walking by, can be perceived in the periphery. This human ability enables us to remain aware of 'what's going on around us' [2], without specifically paying attention to it.

As computing technology is becoming ubiquitous in everyday life, more and more physical objects have the potential to become interfaces. But placing all these interfaces in the center of the attention will likely cause users to be overburdened with information. However, the upcoming pervasiveness of the computer also raises the opportunity for information display to go beyond screens, and allow it to be presented more subtly. This is one of the aims of the area of *calm technology*, "technology that engages both the center and the periphery of our attention, and moves back and forth between the two" [10]. In other words, calm technology enables the communication of relevant information in a subtle and unobtrusive way. This ensures that the user's ongoing activities are not interrupted [3]. Obviously, this kind of technology does not lend itself for urgent information such as an alarm, but seems very appropriate for information that could be relevant, but is not urgent and can therefore also be ignored. Given previously mentioned human auditory perception skills, we see major opportunities for sound to be used in calm technology.

The miniaturization of computing technology has also led to the possibility of using physical, everyday objects for interaction by means of digital technology. This area of research, called Tangible Interaction [6], has gained popularity of the past years. Physical, interactive objects have the potential to provide an embodied representation of the digital state of a system, but also to leverage human skills in interaction with such systems. Tangible Interaction usually takes place in the center of the attention. Therefore, we think that unobtrusive sound (that may be perceived in the periphery of the attention) and physical or tangible interaction (that may take place in the center of the attention) can complement and for that reason strengthen each other in calm technology designs. Furthermore, aesthetics play a role were physical designs are involved. Especially for systems that aim at displaying information, we see an interesting link with the idea of *information decoration*, which "seeks a balance between aesthetics and information quality" [2].

In line with the calm technology vision [10], we present two design cases that explore a combination of unobtrusive sounds and physical interaction to engage both the center and the periphery of the attention. First, we will look into some related work in the area of sonification and calm technology.

2. RELATED WORK

Although most sonifications focus on direct interaction between user and system, some examples exist that apply sound as calm technology. 'Mediated Intuition' [3] for example unobtrusively informs office workers of the current printer queue through sonification. Similarly, 'ShareMon' [1] is a sound based application for monitoring background file sharing events. These examples however, do not incorporate any interactivity. The example of 'Audio Aura' [5], which provides information based on the location of users via background auditory cues, is slightly more interactive because the sonification is triggered by users, be it unconsciously. Also, 'Birds whispering' [2], which makes office workers aware of the activities in the office through bird-sounds, is an interactive system based on the location of users. 'IrisBox' [3] is a system that sonifies availability information of relatives, while a physical interface can be used to indicate your own availability, which makes it a rare example of a meaningful combination of physical interaction and unobtrusive sonification. In this paper, we aim at combining everyday physical interactions in the home environment with sonifications that are perceivable in the periphery of our attention, in order to provide users with awareness of ongoing events in an unobtrusive way.

3. DESIGN CASES

In this section, we will describe two design cases exploring our approach to combine unobtrusive sonification with physical interaction. The two designs, called *Flunda* (Section 3.1) and *Marblelous* (Section 3.2), are developed to be used in the home environment and focus on peripheral awareness of the activities of different family members.

Nowadays there are many families with two working parents. Particularly when children reach an age at which they become more independent (say when they become teenagers), different family members start having different activities and obligations and the family schedule can become rather complex. When members of such families arrive at home, they often quickly check which of their family members are at home. This information can lead to a comforting feeling of knowing that everything is okay. The design cases presented here try to support such families in this need by subtly informing them about the status of family members when they come home or leave.

To inform the design, a creative session with five participants was set up, in which we explored the kinds of information that could potentially lead to a comforting feeling in the home environment. Furthermore, open interviews were conducted with five families in the target group. These interviews centered around rituals of coming home, as well as (existing) sounds in the home environment and the way they are interpreted and valued. The interviews revealed that indirect auditory cues concerning family members in the home can evoke emotional responses. For example, sounds indicating that someone is (coming) home often evoke pleasant emotions. As a result of both the creative session and the interviews, we found that particularly information regarding which of the family members are at home and for how long they have been at home, could lead to a comforting feeling when coming home or when leaving. Therefore, both our design cases aim at unobtrusively presenting this information to people coming home or leaving. Obviously, this information should be presented subtly and is not meant to intrude with the family member's privacy.

To strengthen the link between the physical interface and sonified data, sounds are mechanically generated by the physical interfaces in both designs. Furthermore, the designs are intended to form a (both visually and sonically) aesthetic element in the home.

3.1. Flunda

Flunda is aimed to be used in a hallway and is a combination of a coat rack and an indoor water fountain. *Flunda* consists of five water taps that can pour water onto a wooden surface. Five hooks (one for each family member) are each connected to a tap. When someone arrives at home, he hangs his coat on the rack and the corresponding tap will start to drip. The longer the coat hangs on the rack and thus the longer the person is at home, the greater the jet of water will be. In the first half hour the water will vary from slowly dripping to a higher speed of dripping. After this first half hour the water will start to pour in a small jet. Within 5 hours the jet will enlarge to its maximum. This time range of 5 hours is abstracted from an analysis on a family planning. To avoid privacy issues, the user will not be able to extract the precise time of arrival of family members; the increase in water volume is not big enough for people to make an exact estimate. As the water jets change, so will the sound of the water falling on the wooden surface. Furthermore, multiple dripping taps will sound different than one dripping tap, or one pouring tap. This way, each situation regarding the number of people at home and the time they have been home, will result in a unique soundscape of water falling on the wooden surface, which informs about the situation at home. See Figure 1 for an impression of what *Flunda* will look like. Figure 2 shows an example of how *Flunda* sonifies and visualizes information through water jets, as well as a prototype version of *Flunda*. This prototype was used during the design of *Flunda*, to experiment with different materials and shapes in terms of the sounds they produce. Consequently, we chose to use plywood, as the timbre of water falling on this material was most pleasant to hear. See [7] for a video of *Flunda*.

Figure 1. *3D rendering of the design of Flunda*

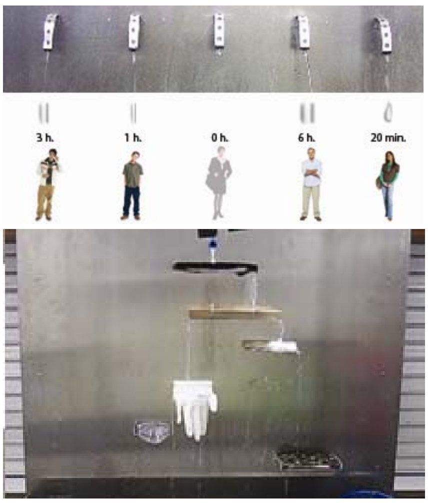

Figure 2. *An example of the sonification and visualization of the information about how long family members have been at home (top), and a picture of the working prototype (bottom).*

To evaluate the design of *Flunda*, we performed an interview with a mother and her eighteen year-old daughter. They were interested in the idea of the comforting information when they would arrive at home. However, they were a little skeptical about whether the information on how long the family members are at home would be useful. Nevertheless, they mentioned that when they come home they often ask the question: For how long have you been home already?

Busy families often live according to a fixed pattern of activities. Therefore they know what the situation will be when they arrive at home. When users get used to *Flunda* they may learn to recognize which sound combinations correspond to which home situations. If this is the case, the user will know what sound to expect when he arrives at home. When the sound matches the expectation, it will likely be perceived in the periphery of the attention, and may lead to a comforting feeling of knowing that everything is okay. However, when the situation is different than expected, the sound may shift to the center of the attention and the user will notice that something is different. In this case, looking at *Flunda* will provide the user with more detailed information about his family members.

3.2. Marblelous

Marblelous is a physical design that provides instant auditory information in the hallway on how many people are at home and how many are away. Different from *Flunda*, the time that people have been at home is not directly displayed.

The *Marblelous* working prototype consists of two glass vases containing a number of identical glass marbles (see Figure 3). One vase represents ‘home’, the other represents ‘away’. The number of marbles in the ‘home’ vase corresponds to the number of family members that are currently at home and the number of marbles in the ‘away’ vase shows the number of people not at home. The number of marbles thus equals the total number of family members. When someone comes home, the ’away’ vase tilts such that one marble rolls in to the ‘home’ vase. As the ’away’ vase tilts, the marbles softly roll and bump into each other. The resulting sounds reveal roughly how many marbles are in the vase and thus how many people are away at the moment. Once the marble rolls into the ‘home’ vase and bumps into the marbles in there, a similar play of sounds provides an indication of how many people are already at home. When no-one is leaving or coming home, the vases take turns in gently tilting up and down, creating a constant, very light soundscape that people in the proximity can tap into or ignore. The vases tilt with different rhythms and never at the same time, which enables distinguishing them in the soundscape.

Over time, *Marblelous* starts to recognize patterns in who is home or away at what times of the day. This is currently not implemented in the prototype, but could be achieved through a combination of learning algorithms and proximity sensors to notice if people walk in or out. When the situation is as ‘usual’, the sounds are subtle as described above. As a situation starts to deviate from the expected ‘usual’ situation, e.g. when someone is working late, the smooth glass surface of the vase over which the marbles are rolling starts to change to a rougher, coarser texture (by rotating it to a different patch of surface, see Figure 3). This causes the sounds to become more irregular and sharp, which may lead to the sounds gradually moving into the center of attention. See [8] for a video of *Marblelous*.

To evaluate the developed prototype, a test with three family members of one family was conducted. The aim of this test was to verify how well the designed sounds could be distinguished. With their backs turned toward the prototype, participants were subjected to an array of twelve soundscapes, each produced by a different number of marbles rolling through one of the vases. After each sound they were asked to indicate how many marbles they thought were present. The participants identified the correct number of marbles roughly three out of four times. When incorrect, guesses were never further then one marble off. Subsequently a similar test was conducted in which the texture rather than the number of marbles was varied. Textures were less accurately identified (correct in roughly half of the cases).

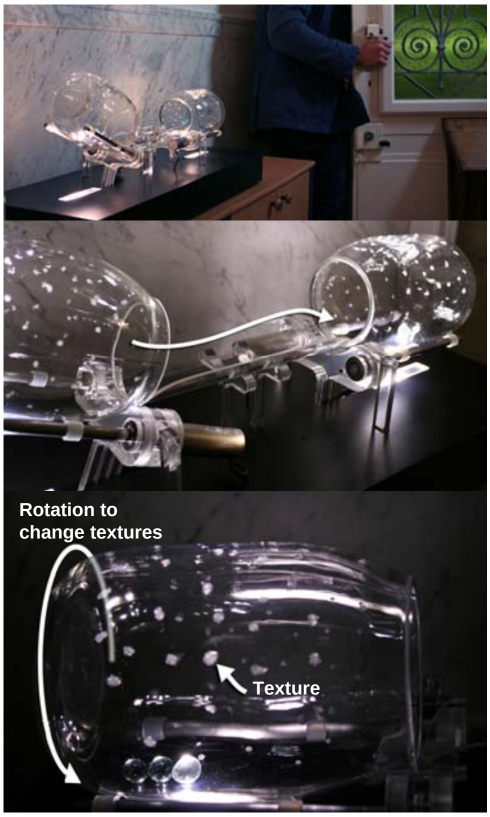

Figure 3. *Marblelous working prototype located in the hallway (top), an illustration of the movement of marbles (middle) and of the changing textures (bottom).*

Having two vases (‘home’ and ‘away’) creates a clear auditory and visual separation between the two states. Furthermore, the marbles and different textures are clearly physically present. Therefore, looking at the physical may provide more detailed information then listening only. In addition, the system and its sounds can be physically manipulated if desired. For example, people can easily manipulate the produced sounds by removing marbles, taking away a vase or rotating a vase to a different texture.

4. DISCUSSION

The two design cases presented in this paper aimed at exploring the combination of physical (everyday) interaction and unobtrusive sonification. Both designs physically and sonically represent information of the activities of family members in the home environment. More specifically, they show which family members are home, for how long they have been at home and whether this differs from the expected situation. User interviews revealed that this information is considered relevant and could lead to a comforting feeling of knowing that everything is okay.

The evaluation of particularly the *Marblelous* design has shown that non-experienced users are able to distinguish and identify most of the different sounds produced by the design.

This indicates that people could be able to extract the relevant information by simply listening to the produced sounds. While not all sounds were distinguished, we expect that as people become more experienced listeners, their ability to pick up the correct information will increase rapidly. In other words, they will ‘learn the language’ of the design.

Although our intention with both designs was to enable users to perceive the sonified information in the periphery of their attention, we have not yet been able to specifically evaluate this. Studying this potential effect of our designs would require longer term experiments, in which the designs are placed in the home environment for a period of time.

The data (information about family members) is perceivable by listening to the sounds as well as by looking at the interface. Listening provides you with general information (e.g. multiple people are home), whereas looking will give you the details (exactly three people are home). The visual information may therefore extend the auditory information. Given the potential of perceiving the auditory data in the periphery of the attention, we think these examples show a valuable combination of physical interfaces and unobtrusive sonification in calm technology designs.

The two designs (*Flunda* and *Marblelous*) have similar intentions; subtly providing users with information about their family members as they come home or leave. Apart from the differences in both physical and sound design, the two designs also differ in terms of mapping. *Flunda* makes the information about how long people are at home directly audible and visible. *Marblelous* on the other hand, interprets this information via a learning algorithm and displays whether the information is different from the expected situation. However, if an unexpected situation occurs, the user is not informed of the exact difference that is at hand. With *Flunda*, this information can be extracted more easily by looking at the physical design. The preferred kind of mapping likely depends on the kind of family using the design and how fixed their daily patterns are. Obviously, neither of the designs is intended to provide precise information.

Both proposed designs use mechanically generated sounds. Although this is not commonly used in sonification, we think it is particularly interesting when sonification is combined with physical interfaces, as was the intention with our design cases. By using mechanically generated sounds, the sonification is directly linked to the physical interface, which strengthens the coupling of the data displayed physically and the sonified data. If the sound would have been generated digitally, the link to the physical interface may have been lost. In that case, the concept of getting more detailed information when looking at the physical interface would be weaker, as users may not directly know that the sound is connected to the physical object.

Apart from being informative, we also see an aesthetic value of the two designs presented in this paper. This also refers to the earlier mentioned idea of *information decoration* [2]. The longer people have a design like this in their home, the better they will be able to interpret the information provided by both sound and physical object. This means, that there may be different kinds of users; experienced users (people living in the house in question) and novice users (visitors). This last kind of user will not be able to extract as much information from the system as experienced users will. In fact, they may not have any idea of what the sounds or physical states mean or even that they mean anything at all. Although the systems are obviously not primarily designed for this kind of user, an interesting thing is that even though the interfaces may not have an informative value, they will still be decorative to novice users. This may prevent users from being overburdened with information that may not be relevant to them.

Having demonstrated a way to valuably combine physical designs with subtle sonification, we see many opportunities for taking this a step further. Therefore, our future projects will aim at exploring this approach for other kinds of information, as well as for other application areas, which will also include longer term experiments with new sonifications.

5. CONCLUSIONS

The design cases described in this paper provide an example of calm technology by using sound in (physical) interactive systems and aim at leveraging human perception skills to unobtrusively communicate information. Although this may not be a classic example of interactive sonification, we think it points out interesting new opportunities for using sound in interactive systems. With the increasing miniaturization of computing technology, intelligence and thus information can be everywhere nowadays. Presenting this information in a subtle and unobtrusive way enables users to perceive it either in the periphery or in the center of their attention.

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