

# Subtle and Public Notification Cues for Mobile Devices

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**Abstract.** Mobile information technology increasingly influences everyday life. When used in social contexts several problems regarding how mobile devices convey notifications arise. Auditory notification cues, such as those generally used by mobile phones, can be intrusive and attention demanding. Tactile cues, such as vibrations, are very private and subtle. However, since it is hard for other people nearby to perceive such cues, it can be awkward to understand the actions which a notification cue can give rise to, i.e., tactile cues are not public. We discuss the design space of notification cues for mobile devices and propose an exploration of the space which combines the two dimensions of subtlety and publicity. We conclude with a description of current and future work.

## 1 INTRODUCTION

Mobile information technology such as mobile phones and PDAs (Personal Digital Assistants) can provide users with services that make it easier for them to keep themselves available to and contact others, to organize their time and to become notified of important events. There is a great interest in such devices among both professionals and consumers. One consequence of the proliferation of mobile information technology is that its use influences almost all social situations including situations outside the typical work setting, since the device is on at all times and follows its user rather than being bound to a specific location (e.g. work or home).

One of the prime functionalities of mobile devices is to notify their users of certain events. For instance, mobile phones notifies users of incoming calls, and PDAs convey notifications regarding events scheduled in the users' digital calendars. Notification cues emanating from these devices are in many situations perceived as inappropriate, both by the owner of a device and to the people nearby. Problems regarding how notifications are conveyed from mobile devices, in particular in social settings, need to be addressed.

In this paper, we explore complementary ways of conveying notifications from mobile devices. The ambition has been to explore various notification cues which might be more socially acceptable. First we discuss some of the problems with notifications, and then sketch the design space of notification cues for mobile devices. We conclude with a description of current and future work.

## 2 BACKGROUND

Presently, notifications from mobile devices are conveyed mainly by sounds and beeps, and to a lesser extent by tactile cues such as vibrations. Below we will present problems specific to the use of auditory and tactile notification cues in social settings, and also introduce a few terms which can be helpful when trying to understand the issues involved.

### 2.1 Auditory Notification Cues

Current auditory notification cues can be attention demanding, distinct and intrusive and therefore be perceived as inappropriate in many social situations. Ling writes: "The beeping and ringing is by nature an intrusive sound not unlike the sound of an alarm clock" [1], referring to the different auditory cues used by mobile phones. The individual user often address such problems by disabling the notification cue in certain social contexts, such as at business meetings or at the cinema [1, 2]. It is questionable, though, whether this is a satisfactory solution, since the notification cue might convey information which is both important and valuable to the user.

This question is related to the problem of communication deficiency as defined by Ljungberg and Sørensen: "Communication deficiency characterizes situations where people are subjected to communication which they are interested in, but where the mode of communication is undesired" [3]. Auditory cues for mobile devices are typically designed to attract maximum attention and to be able to penetrate even a very noisy sound environment. The notification in itself requires the recipient to, more or less instantly, direct her attention towards it.

We use the term *attention overload* to describe the phenomenon which arises when people are overwhelmed and interrupted by intrusive and attention demanding external events, such as loud auditory cues or flashing bright lights. Attention overload concerns not only the owner or holder of a mobile device, but also other people nearby. They might not have an interest in an auditory notification cue conveyed by someone else's device, but their attention is still very much drawn to it.

We use the term *subtlety* to describe how well a notification cue conveys information in a non-intrusive and gentle manner. Vibration, for instance, has the advantage of being very subtle. An intrusive notification cue might, however, contribute to the creation of attention overload since it, in social contexts, often demands the attention of the user as well as of other people nearby.

### 2.2 Tactile Notification Cues

Tactile notification cues are sometimes problematic in social environments. A vibration is an example of a tactile notification cue, and a device which conveys notifications using such a cue is typically carried close to the body to enable the user to perceive the notification. Thus, the device is typically not very visible to other people in the user's surroundings, and it can be difficult for them to comprehend the user's

reaction to a ‘hidden’ and personal cue, i.e. the device’s notification cue is not *public*. However, a traditional wrist-watch is public to the extent that it is often worn visible to others and when the user looks at it and walks away, it is a situation which people usually interpret in terms of causality. But, consider the following scenario:

*Sharon is standing in the corridor with Reynolds and Mark, telling them about the latest board meeting. Suddenly Sharon’s mobile phone, placed in her pocket, starts to vibrate. Sharon feels it, stops talking, and picks up the phone to say -Hello.*

To Sharon it was perfectly natural to pick up the phone and answer, because she had felt the vibration cue and had understood that someone wanted to reach her. To Reynolds and Mark, on the other hand, their ongoing conversation was abruptly interrupted since they had received no forewarning of what was about to happen. They could not, as Sharon, interpret the situation at hand, because the notification cue was hidden to them. Due to this, Sharon stopped taking part in the conversation. This could have happened even if the notification cue had been public, but now the social interaction between them was further disturbed. Handsfree headsets for mobile phones have introduced a similar issue, where people can appear to be talking to themselves, because their headsets are hardly noticeable to others [4].

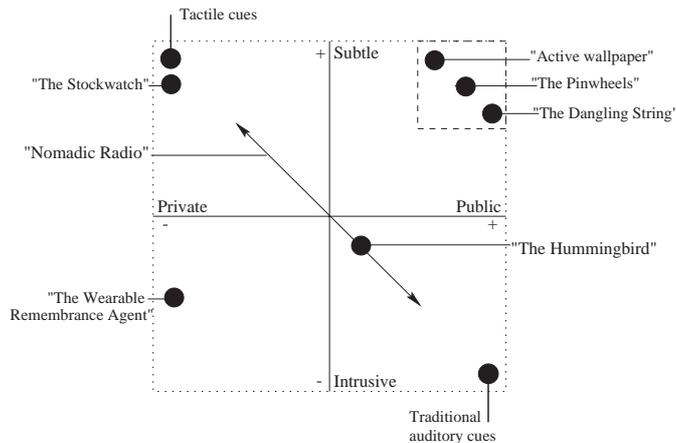
A *public* notification cue initializes a course of events which is transparent to people near the person receiving it. An auditory cue from a mobile phone is public and people in the user’s surrounding can easily understand the relation between hearing an auditory cue from a mobile phone and seeing someone pick up a mobile phone to answer. A non-public, i.e. private, notification cue initializes a course of events which is hidden, more or less, to people nearby the user of the device. It might increase the risk for misinterpretations of a user’s actions in social environments.

### 3 COMBINING SUBTLE AND PUBLIC QUALITIES

By creating a model spanning these two dimensions and characterizing related research in relation to the model, we hope to better understand the complex relationships between subtleness and publicity with regard to notification cues. Figure 1 illustrates two dimensions of modes of notifications; subtle vs. intrusive, and private vs. public, represented as a two-by-two matrix.

To avoid social misinterpretations as well as the problem of attention overload, it is desirable to design notification cues which combine the qualities of being subtle and public. Today very few mobile devices convey notifications in both a subtle and public manner. Thus, we suggest an exploration of the area which is indicated in the first quadrant in figure 1. Such notification cues would function as a complement to already existing notification cues.

Depending on what context the user of the mobile device is in and on the nature of the information conveyed, different kinds of notifications cues need to be used. The kind of notification cues investigated here are especially intended for use in social contexts where there is a need for immediate response from the user. The cue would ideally be subtle enough to avoid being intrusive and public enough to make the transition



**Fig. 1.** A model for visualizing subtleness vs. publicity with regard to notification cues.

between the user receiving a notification cue and instantly responding to it comprehensible to people nearby. However, when the user is not in a social context or when the user receives notifications which do not need to be responded to at once, a tactile cue could be quite sufficient. An auditory cue can be the best choice in other situations; it can for instance convey more complex notifications, such as verbal messages. It is a challenge to successfully combine various modalities and notification designs with different contexts of use. Several context-aware mobile systems that change their manner of notification depending on what environment its user is in [5, 6] and on what information is to be conveyed [2] have been developed. We will not elaborate more on technical issues here since it is beyond the scope of this paper.

### 3.1 Related Work

The concepts of *calm technology* [7] and *ambient displays* [8] have inspired this research as they are non-intrusive in character and mostly convey information publicly. A number of systems have been characterized: public as well as private and subtle as well as intrusive systems (see fig. 1). *The Stockwatch* is a personal and mobile ambient display which uses temperature to convey information about changes in stock rates [9]. The back of a watch becomes a display which changes its temperature depending on fluctuations in the user's stock. *The Hummingbird* is a small portable device which supports social awareness between people who frequent the same physical location [10]. If two people, carrying Hummingbirds, are in each other's vicinity the Hummingbirds starts to vibrate and "hum", making the users aware of each other's presence. *The Wearable Remembrance Agent* uses a headworn see-through display and acts as an *augmented memory* for its user by displaying timely text messages [11]. *Nomadic Radio* is a wearable notification tool which uses audio messaging to convey scalable

and contextual notifications. It conveys notifications differently depending on message priority, usage level, and environmental context [2]. *Active Wallpaper* is an ambient display which makes its spectators aware of the human activity at the workplace by projecting light on a wall [8]. *The Pinwheels* is an ambient fixture which visualizes an artificial airflow and uses it as a medium to convey different sorts of information [12]. Finally, *the Dangling String* is a piece of art by Natalie Jeremijenko, often used as an example of calm technology [7]. It is an eight foot long ethernet cable, connected to a small motor mounted in the ceiling. It vibrates at different speeds depending on the activity on the adjacent computer network.

Four of these systems are not situated within the first quadrant, i.e. they do not combine subtle and public properties. The Stockwatch is very private and the notifications which it conveys are not perceivable to anyone but its user. It is also very subtle since it conveys the information using gradual temperature changes. Due to this, it is situated at the upper left corner of the second quadrant. The Hummingbird is the only device that lies within the fourth quadrant; it is public to the extent that it emits a soft sound when it detects another Hummingbird, but since it uses an auditory cue it can be perceived as somewhat intrusive. The Wearable Remembrance Agent is placed in the third quadrant; it is very private, but it is also intrusive to a certain extent since its user needs to explicitly focus on the display in order to receive the information conveyed. The headworn display can also cause disturbance in social settings. People can, for instance, find it difficult to have a conversation with someone wearing such a display. When trying to place the Nomadic Radio system in the model, we found that since it changes its notification cue depending on what context its user resides in, it cannot be placed at a fixed point in the model. Rather, it continuously moves between different places in the model, from being subtle and private to being louder and more public. Its movements is illustrated by the diagonal line in the figure. The Dangling String, on the other hand, is public and calm and therefore situated within the indicated area in the first quadrant. Active wallpaper and the Pinwheels, being public and subtle ambient displays, are also located within this area.

Two of the described systems are very private, one is public and intrusive, one moves between different states while three of them are situated within the specified area. The Stockwatch, for instance, is very subtle and private, which is well suited for its application - personal stock information should probably not be very public. Since it conveys a very *slow* notification cue which the user does not have to respond to directly there is no need for such changes. It could be discussed though, whether the Hummingbird could convey its notifications in a more subtle manner or not. Most importantly this illustration indicates that we can learn from calm technology and ambient displays when attempting to combine subtle and public qualities.

## 4 CURRENT AND FUTURE WORK

The Reminder Bracelet was our first effort to create a design example within the indicated area [13]. It is a bracelet which is connected to a PDA and it conveys visual notifications regarding events scheduled in the PDA's calendar. It is an attempt to combine

the properties of subtlety and publicity when designing notification cues, and also to draw on the properties of calm technology and ambient displays. Informal formative studies have been conducted and even though the prototype's technical implementation could be improved, the underlying concept was clearly understood by the users and they all responded positively to it. They commended the ambition to design notification cues with a low demand for the user's attention as well as a high level of acceptance in social contexts.

However, it was also clear that the users felt that the concept of subtle and public notification could be further improved. Thus, the design space of subtle and public notification has to be explored using more design examples based on other approaches to these problems as well. Another issue of importance in future work, concerns the reactions by people in the user's vicinity. We need to perform studies of people in social contexts in order to learn more about the impact of different forms of public notification.

#### **4.1 Personalization**

We are exploring the design space of notifications on several different levels and besides continuing the work on subtle and public notifications we are looking at notification cues from a less functionality focused point of view. Besides the apparent functional use, mobile notification cues are increasingly used to express symbolic and personal attributes related to lifestyle, personal image, etc.

Given the importance of the "personalization" [14] of technology as it enters our everyday life, the design of notification cues might have to be approached from a different perspective. When designing for personal expression, we will explore emotional and expressive values. For instance, we can use approaches such as the one used in [15], where experimental design of information appliances were used to explore its possible emotional and aesthetical role.

In the case of mobile phones, people have found their way to personal expression by means of re-programmable melodies. A powerful possibility would be to enable people to combine several different kinds of notification cues. This would open up for a richer variety of ways for a person to find her own expression. The future challenge would then be not so much to support reprogramming of existing notification tools, but to come up with entirely new ways for devices to notify their users that also enable people to express themselves in various ways.

Obviously, exploring the design space of notification cues from this perspective is very different from exploring it from a functional point of view, and we strongly believe that it is valuable to combine these perspectives.

## **5 CONCLUSION**

In this paper we presented several issues regarding the use of notification cues in social contexts. We suggested to combine the properties of subtlety and publicity when

designing notification cues in order to make them fit more smoothly into social settings. The Reminder Bracelet was a first design example, but the design space of subtle and public notifications has to be further explored. More design examples should be developed and several user studies need to be conducted. It is also important to consider personal expressions in relation to notification cues.

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