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Developing Tactile Icons to Support Mobile Users with Situationally-Induced Impairments and Disabilities

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ABSTRACT
Although it is well known that interaction with a mobile device can be impacted when the environment is inhospitable or when the user is on the move, situationally-induced impairments and disabilities (SIIDs) are often overlooked in the mobile interface design process. In this paper, we describe one step toward supporting mobile users with SIIDs, through the design of tactile notifications. The tactile channel offers considerable promise to convey notifications to the user, freeing their visual and auditory channels for other tasks. A study was conducted to determine whether participants could develop tactile cues to convey the key characteristics of alerts to mobile users (e.g. urgency, relationship with the sender). The results highlight the benefits of tactile prototyping tools to encourage generation of design ideas, and the use of scenarios to situate these design ideas within the intended context of use.

Categories and Subject Descriptors
H.5.2 User Interfaces – *Input devices and strategies*

General Terms
Human Factors

Keywords
Situationally-induced impairments and disabilities; Tactile

1. INTRODUCTION
Graphical or auditory alerts are intended to heighten awareness of incoming messages or system-related events among mobile users. However, depending on the context of use or the environment where the user is located, cues may fail to capture the user's attention. Tactile feedback can offer considerable potential to mobile users with situationally-induced impairments and disabilities (SIIDs). Vibrations presented via the mobile device can remain effective in some inhospitable environments where other cues may become ineffective (e.g. when in noisy surroundings where auditory cues from the phone would ordinarily be masked). Tactile feedback can alert users who are on the move when attention cannot be shifted from the path ahead to visually monitor the mobile interface (e.g. when walking or driving a vehicle).

In this paper, we describe a study examining the ways in which characteristics of notifications (e.g., message urgency, relationship with the sender) can be mapped to the tactile feedback to support mobile users with SIIDs. Our focus is on developing tactile notifications which convey meaning to the user.

2. RELATED WORK
Researchers have examined the conditions under which mobile devices are used, to determine the impact of SIIDs on interaction [2,4,5]. For example, in a study examining targeting and reading using a touchscreen device, Schildbach and Rukzio [5] identified that performance decreased and cognitive workload increased significantly when walking compared to standing. Kane et al. [2] investigated whether altering size of targets could be an effective strategy to reduce the negative effects of mobile interface usage when ambulatory. Although larger targets were found to be easier to identify, their dynamically adapting solution did not result in the performance gains envisaged.

Tactile feedback can play a vital role in supporting mobile interactions. Short bursts of feedback (i.e., "tactons") can alert users in situations when discretion is required or when the environment is inhospitable. Parameters of touch (e.g. duration of and interval between stimuli, location of presentation, amplitude, frequency) can be manipulated to form unique experiences, which can be integrated within an interface. However, these cues are often arbitrarily selected by interface designers without consideration of the meaning users may associate with the tacton. As a result, time and cognitive effort can be spent learning these associations. Arbitrary selection is, in part, attributed to the difficulty involved in eliciting tactile design ideas from users as a result of the challenges associated with describing touch-related concepts. The language of describing tactile phenomena is often limited to a small selection of words [3].

3. STUDY DESIGN
A study was performed to develop meaningful tactile cues for mobile users with SIIDs. Twenty smartphone users (7 female and 13 male, average age: 32.6) were recruited for the study. All acknowledged experiencing SIIDs, resulting in alerts being inaccessible or missed.

Each participant was presented with a set of rich stories (*scenarios*) examining the needs of mobile device users who were constrained by the context of use or environment where the interaction was taking place. Scenarios were presented to enable participants to empathize with the specific needs of the situationally-impaired user, with the goal of stimulating discussion regarding the ways in which tactile feedback could be used to support him/her.

Examples of scenarios included: (1) when in a business meeting, a hospital representative calls notifying the user that a close relative has been involved in an accident and he/she should urgently make contact, (2) when a user is driving with attention focused on the road ahead, a text message from the user's spouse asking him/her to purchase supplies for dinner, and (3) while a user is walking along a noisy street where sound from the mobile device is inaudible, a reminder is received from a colleague notifying the user that an important meeting will start in half an hour.

Participants were asked to identify ways to convey specific characteristics of notifications through tactile feedback. The characteristics selected for this study were based on findings from a pilot data gathering study examining reasons for mobile phone usage. These included (1) urgency of the message, (2) relationship with the sender (i.e. whether close or not), (3) the frequency of communication between the sender and receiver, (4) size of the message (i.e. long or short). Participants could design tactile cues using prototyping software (Contact Vibrate [1]) on a mobile device (Android operating system), where vibration patterns created could be replayed as many times as needed.

4. RESULTS AND DISCUSSION

Participants were all able to describe instances when they had received mobile notifications but due to the situation or context (e.g. when in class, when hands are occupied when carrying bags), decided to wait until a more appropriate time after completion of the activity to check their messages. They welcomed the concept of personalized tactile notifications, as it would alleviate the burden on the visual and auditory senses. One participant was particularly interested in a tactile feedback solution, as a discrete vibration would reduce the likelihood of third parties being able to identify when incoming messages were received.

Although participants were observed initially experiencing difficulties verbalizing tactile design suggestions, they were able to provide analogies from their own experience using other systems (e.g. vibrations from gaming peripherals) or by describing sounds (e.g. if the notification is important, an alert similar to that of a fire alarm should be presented). Observations from the interviews revealed that providing prototyping design tools enabled them to experiment with ideas, which they could replay on a mobile device. They would then simulate the actions undertaken by the *actor* or main character in the scenario, to better understand their needs and to determine whether the tactile feedback would match the needs of a mobile user with SIIDs. Based on this feedback, the design ideas could be strengthened or further suggestions could be made.

The tactile parameters used to encode prototypes were analyzed, to identify trends among designs. Fifteen of the twenty participants used the parameter of intensity to convey urgency. They suggested that perceivably stronger sensations would immediately signal to the user to terminate their current task with the objective of responding to the notification more quickly. Seventeen participants suggested using duration of tactile icons to convey information regarding the size of the message. Longer lasting vibrations were thought to better represent a longer incoming message where the user would need to spend time reading and responding. Analysis revealed that the longer tactons suggested by study participants would last on average of 2.3s (0.6s SD), while shorter notifications would last 1.2s (0.3s SD). A number of participants thought that they would be able to estimate the amount of time needed to process the incoming notification, and therefore they could use this information to help them to decide whether to stop the task at hand to attend to the notification.

Eleven participants designed tactons with shorter intervals between tactile stimuli to represent frequent levels of contact between the sender and recipient (i.e. that messages had passed between the parties multiple times that week). Analysis of the prototypes developed revealed that on average, intervals would last in duration for 0.8s (0.2s SD) for frequent contacts and 1.5s (0.3s SD) for infrequent contacts.

Sixteen participants suggested that presenting tactons at different positions on the body through wearable attachments (e.g. watch, bracelet), would best convey to them the relationship with the sender. For example, receiving a message at an intimate site (e.g., inner side of wrist), was thought to communicate to that someone special (e.g. friend or partner) had sent a message. They also suggested that there would be a lower likelihood of missing the tactons presented as the wearable attachments would be close to the skin. This was in contrast to situations where the phone is placed in a trouser pocket and cues are attenuated due to the clothing barrier.

The tactons developed by participants were relatively simple in structure. Design decisions were, in part, motivated by concerns associated with having to learn the tactons, particularly in situations where attentional resources were in demand (e.g. when driving). However, recognition abilities were thought to improve with practice. As SIIDs are temporary in nature, suggestions were made to dynamically adapt feedback based on the situation or context. For example, if the device could detect when the user begins to walk, stronger feedback could be presented to reduce the likelihood of missing the cues. To address this issue, we have begun to examine the tactile perceptual difficulties encountered by mobile phone users when ambulatory [4]. We also aim to explore the extent to which tactons developed as part of this process can support individuals with health-induced impairments and disabilities (HIIDs), which unlike SIIDs may be permanent in nature. Future work may focus on users with attention deficits.

5. CONCLUSIONS AND FUTURE WORK

This paper describes a study designed to develop tactile notification prototypes for mobile users with SIIDs. The next logical step for the research is to evaluate these tactons in the field, to better determine their efficacy when encountering SIIDs. These tactons can be compared against arbitrarily-selected tactons to assess the merit of encouraging target users to design their own tactile feedback. Insights from these studies can offer valuable guidance as mobile designers seek to develop interfaces that better address the effects of inhospitable environments and varying contexts of usage on mobile interaction.

6. REFERENCES

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