Investigating User Preference for Mobile Auditory Notifications in Different Contexts

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Abstract
Notifications received on mobile devices such as smartphones or smartwatches have become indispensable. Apart from visual and haptic ones, especially auditory notifications are common. While often different applications use different sounds, the user's context is only seldom taken into account. In this paper, we investigate how people perceive auditory notifications depending on different contexts. Our results indicate that consistent notifications, e.g. a nature sound in a forest environment, are preferred.

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Notifications; context awareness; auditory

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H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction & Related Work
Notifications are an integral mechanism of today's smart devices to inform users about incoming events such as emails or text messages, but also other information, e.g. through a digital assistant like Google Now. In 2014, an in situ study by Pielot et al. [9] showed that on average more than 60 notifications are received per day. An investigation on users' awareness of notifications [13] revealed that the amount is often underestimated by the user and

even up to 200 notifications can be observed. As shown by Leiva et al. [6] unexpected interruptions can cause a significantly high runtime overhead of up to 400%. Previous research has investigated how the presentation modality (see e.g. [7]) or the device that shows the notification (see e.g. [12]) influences a user's reaction to the notification. Another interesting aspect that has been observed in the past is the context the user is currently in. For example, Kern and Schiele used the current context (derived from different sensors) to decide whether notifications should be shown at all and if so, using which modality [5]. Regarding typical modalities used for notifications on wearable, especially wrist-worn, devices, there are in general three types that come to mind: visual, haptic and auditory. While recent research mainly addressed the first two types (see e.g. [4, 8, 10]), not so much has been done for the latter. Gallud and Tesoriero [2] presented the results of a questionnaire investigating, among other things, which modality people prefer for their notifications. Their results indicate a clear preference for sound-based notifications, partially in combination with other modalities such as vibration. Garzonis et al. [3] investigated different types of sound notifications, but their focus was more on aspects such as recognition accuracy or mapping to certain services. In contrast to these approaches, we take auditory notifications as granted and investigate how different sounds are perceived depending on the environment the user is currently in. This is different from how notification sounds are mainly used today, as distinctions are typically based on the issuing application or in relation to the trigger (e.g. the sender of an email). We suppose that people prefer notification sounds that match the context the user is currently in, as this leads to a consistent user experience.

User Study

We divided our user study in two parts – in a pre-study, we first selected sounds that share certain properties to allow for a fair-minded comparison in different contexts. In the actual study, we evaluated the pre-selected sounds in different environmental situations.

Pre-Study: Sound Selection

We selected 16 different sounds that could be adapted as notification sounds from four different categories: (1) industrial sounds (e.g. the stroke of a hammer), (2) office sounds (e.g. a printer), (3) nature sounds (e.g. a bird song) and (4) artificial sounds (as known from typical notification sounds). All sounds were edited to be of equal length (1.75 seconds) and loudness. We recruited twelve participants (5 females, 28.4 years old on average (25 to 34 years)) to evaluate the selected sounds. Participants were invited to a quiet laboratory environment and additionally equipped with active noise-cancelling headphones (Bose Quiet Comfort 25). The sounds were presented to them in random order and for each sound, two ratings were to be given: (a) "The sound is enjoyable/pleasant" (on a scale from 1=strongly disagree to 7=strongly agree) and (b) "The atmosphere of the sound is ..." (on a scale from 1=dark/negative to 7=friendly/positive). The participants could repeat the individual sounds if desired until they were content with their decisions. In total, the procedure lasted around five minutes per participant.

Not surprisingly, the sounds with the lowest perceived pleasure and darkest atmosphere where those from the group of industrial sounds, whereas the artificial and nature sounds were mostly perceived as enjoyable and having a positive atmosphere. Based on the given answers, we selected two pairs of sounds that reached nearly equal ratings: The first pair is made up of an office sound (line-

Figure 1: Nature background used in our study to generate a consistent impression.

Figure 2: Office background used in our study to generate a consistent impression.

feed of a typewriter, pleasure=4.25 (min=2, max=6), atmosphere=4.75 (min=3, max=6)) and a nature sound (bird song, pleasure=4.5 (min=1, max=6), atmosphere=4.75 (min=2, max=7)) and the second one consists of an artificial sound (pleasure=5.67 (min=5, max=7), atmosphere=6.5 (min=5, max=7)) and a different nature sound (bird song, pleasure=5.75 (min=4, max=7), atmosphere=6.42 (min=5, max=7)).

Main Study: Effects on the Perception of the Environment
As introduced before, we were interested in the effects different auditory notifications can have depending on the environment the user is currently in. To investigate this, we recruited eight participants (4 females, age 28.1 years on average (22 to 33 years)) to a laboratory study. We prepared two scenarios – an open-plan office and a forest. In the first environment, we used the office/nature sound pair whereas in the second, we chose the artificial/nature pair. To create the illusion of the aforementioned environments, a corresponding image (see sidebar) was shown to the participants on a laptop display (MacBook Pro, 13", resolution 2560 $\times$ 1600 pixels) and accompanied with environmental-typical background sounds. To improve the impression in contrast to just seeing a still image, a slowly-moving "Ken-Burns effect" was applied. After a short introduction explaining the motivation behind the study, the participants were given a stand-alone smartwatch (Simvalley AW-421.RX) that is equipped with a speaker so that the device is able to play notification sounds. We presented the participants a notification sound and instructed them to touch a button on the smartwatch's display whenever they hear the specific notification sound. The order of the environments as well as the order of the sounds in the environments was counter-balanced to rule out any carry-over effects. To give the participants the possibility to dive into the environment, no notification was presented within the first 30 seconds after a scenario was started. After this period, five notifications were issued per scenario with a random delay of 15-30 seconds between them. After this, the participants were handed a questionnaire consisting of eight rating questions (presence questionnaires of Slater, Usoh and Steed (SUS) [11] and Barfield and Weghorst [1]) and then, the procedure was repeated for the other sound/environment. After both sounds of an environment were evaluated, the participants were also asked for their preference. In total, the study lasted 22.5 minutes on average.

Regarding the users' preferences, all but one participant chose the nature sound when in the forest environment. Among the reasons for their choice, the participants reported that the sound is "less annoying and distracting" (P5, P6), "less interrupting in the experience" (P4) and "integrates well in the environment" (P2). Only P1 chose the artificial sound and justifies the decision by the fact that the sound is easier to notice as it does not fit in the environment. Of interest is the distinction e.g. P7 made – in both scenarios she chose the nature sound, in the nature environment with the goal not to be disturbed too much in her spare time and in the office scenario (which she associated with being at work) as it is easier to notice so that she can check notifications faster. Similar reasons were given by P1 and P6. Despite the results from our pre-study, two participants selected the nature sound in the office environment because they found it "more positive and less annoying". In contrast to these findings, no statistically significant differences can be found when analyzing the results of the two questionnaires. However, this is not really surprising when considering the overall level of presence achieved in our setup (average SUS score of 1.1).

Discussion

The results from our user study point in the direction we anticipated before – people preferred the sounds that "match" the environment in order to be less disturbed – especially in a scenario that is typically associated with leisure activity. In contrast, a "non-matching" sound is preferred to ensure a better recognition of a notification. Unfortunately, the test setup was not persuasive enough to observe a statistically significant difference in people's perceived presence in the virtual environment. In part, this is related to the evaluation of the SUS questionnaire that only considers scores of 6 or 7 as relevant, i.e. differences caused by lower scores (e.g. a value of 1 in the first condition and 5 in the second) are not considered.

Conclusion & Future Work

Our work provides first insights in people's preference regarding the selection of auditory notifications for mobile, wrist-worn devices. The qualitative evaluation reveals different rationales people have in mind when selecting a notification sound for a specific environment and the consequences w.r.t. the sound selection.

For future work, there are three aspects that could be taken into account. First of all, a more realistic environment should be considered for the study to increase the general level of presence. For example, a walk in the woods could be organized to test different notification sounds in a realistic environment. Second, it could be worthwhile to investigate different notification sounds for different types of notifications, e.g. email vs. messenger notifications. Furthermore, the effects of an automatic adaptation of notification sounds based on an (ideally automatically detected) environment could be investigated.

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