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# Unobtrusive notification based on auditory changes in ambient music

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**Abstract**—Notifications are an indispensable aspect of the user experience with smart devices. However, the increased usage of smart devices yielded proportional increase in notifications. Research has shown that increased notifications may reduce the efficiency of users during tasks, as they are interrupted, and their attention is drawn toward the notification. Therefore, our work investigates a novel notification method based on ambient music, which is background music that was found to unobtrusively motivate users and increase their focus during work. Accordingly, we designed a preliminary study to investigate increased music loudness and duration of increase as basic parameters for designing unobtrusive ambient music-based notifications. Based on extracted insights from our previous study, we follow with a deeper study comparing user impressions and usability of ambient-music notifications with those of common notification. Our results show that most of the participants were able to recognize our notifications, while having minimal effect on their concentration during the task. We discuss some challenges in designing notifications based on ambient music, especially about user preferences of sound loudness and its relation to task type. Lastly, we provide our conclusion and discuss future research direction.

**Keywords**—Auditory Notifications, Ambient Music

## I. INTRODUCTION

Nowadays, smartphones and smartwatches have become an indispensable part of people's lives. The popularity of these devices enabled users to interact with information in a variety of methods. An important part of the users experience with modern devices is notifications, which present a mean to convey various information, such as when receiving a new email or remind users of a calendar event. Various mediums are used to deliver notifications, as visual messages, auditory tones or haptic vibrations.

Although notifications have become an integral part of the user experience with devices [1], with further usage of devices and applications, the number of notifications proportionally increases. The increased number of notifications has been found to negatively affect the user experience, such as to cause confusion and stress [2]. Particularly, notifications can degrade a user's efficiency as they constantly interrupt users' attention and focus, which is especially prevalent in high workload tasks [3].

Such aspect presents a research challenge to design and manage notifications to mitigate their negative impact on efficiency. For example, recent studies have proposed a mobile notification management system that rejects or delays notifications that are not useful to users [4]. However, while such method can reduce the frequency of interruptions, it

does not fundamentally resolve the negative cognitive effects when the user is interrupted and distracted during a task [5].

Accordingly, we investigated a new method of conveying notifications based on ambient music that can potentially convey information without obstruction. Ambient music is commonly listened to during work to increase motivation and focus without obstructing users work. Therefore, we exploit parameters within ambient music, focusing on music loudness levels and duration of change in loudness, to design unobtrusive notification. In this study, we investigated auditory transmission methods that allow users to recognize notifications without interfering with concentration. As a preliminary experiment, we investigated the parameters of the optimal amount of sound change and change time as unobtrusive notifications. We then investigated the mental and cognitive impact on users of the proposed experimental notifications compared to general notifications.

## II. RELATED WORK

**Auditory Notifications:** Previous studies have investigated how changing various musical parameters in notifications affects user perception [6]. Changes in musical parameters cause different cognitive responses and behavioral performance [7]. Auditory changes to the notification may make the user perceive the notification without degrading behavioral performance. Therefore, we are encouraged to investigate how changeability of ambient music attributes, such as loudness and duration of change, can contribute to better delivery of unobtrusive notifications.

**Ambient Music:** previous research has found that background music can help users to concentrate while studying or working [8], and to maintaining high motivation during difficult tasks [9]. Ambient music has been found to have varied effects on users' concentration, for example, background music that the user recognizes and likes can degrade concentration [10]. Therefore, ambient music is usually designed to be unobtrusively played in the background while also contributing to increasing attention and concentration on other tasks. Brian Eno, an advocate of ambient music, summarizes this concept with, "ambient music is interesting but negligible" [11].

Therefore, our approach exploits the concept of ambient music to deliver unobtrusive notifications by investigating parameters of loudness and duration as means to convey inconspicuous information. The type of ambient music should be generic and unrecognizable by the user, therefore, we base this study on a music track that is especially designed by Brian Eno (Further discussed in the next section).

### III. APPROACH AND ITS EXPERIMENT DESIGN

An unobtrusive notification approach is needed to carefully balance the trade-off between drawing the user's attention to the notification information while minimally drawing attention from the main task at hand. Previous works show that the volume of music, even if music is pleasant, can disturb users focus [12]. Therefore, we focus our preliminary investigation on exploring how unobtrusive notification can be designed based on changeability of music loudness.

Our overall objective is to design notifications that convey information while drawing minimal amount of attention, during engaging-tasks (e.g. studying, working...etc). As shown in Figure 1, our unobtrusive notifications approach utilizes changes in ambient music played in background. a) the user may play any background music. b) when a notification is executed, the background music changes in loudness, and remains for a specific period, after which c) the loudness returns to the original state (as in a). Users identify the changeability of volume as notifications, where loudness level and duration of increased volume can be used to convey information unobtrusively.

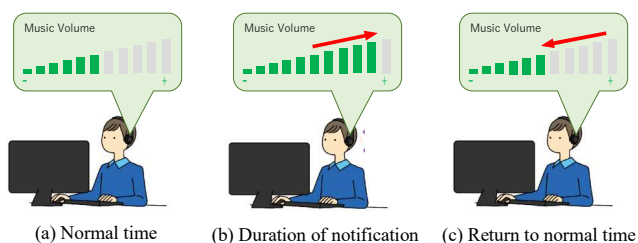


Figure 1. Proposed notification approach.

### IV. PRELIMINARY SURVEY

This preliminary survey investigates the volume changes suitable for users as an unobtrusive notification in ambient music. Therefore, this study focuses on the effects and user impressions of a sound's loudness and duration changes on awareness of a delivered notification as well as its perceived obstruction to the user during notification delivery.

We prepared nine different volume change notifications based on 3 sound loudness levels (15db, 20db, 25db) and 3 sound change durations (2s, 3s, 4s). In each condition, two audio changes occur during the playback of ambient music of about 23 seconds. We selected those parameters based on our preliminary evaluation of various sound parameters. The conditions are shown in Figure 2.

We recruited eight participants (1 female) aged 22-24 years. Participants used a headphone to listen to nine notifications. We used the song "Ambient 1: Music for Airports, 1/1" by Brian Eno for this experiment. After the experiment, participants ranked the notifications in terms of notification awareness and obstruction from first to third.

From the ranked results, the total score of each condition was calculated with 3 points for first place, 2 points for second place and 1 point for third place (Figure 2).

The results show that 25dB loudness variation had highest ranking for awareness and obstruction. 20dB loudness variation was found to produce relative awareness but not highly obstructive overall. Lastly, 15dB loudness variation was ranked lowest with minimal obstructive and minimal awareness, where conditions 1 and 2 were not favored at all.

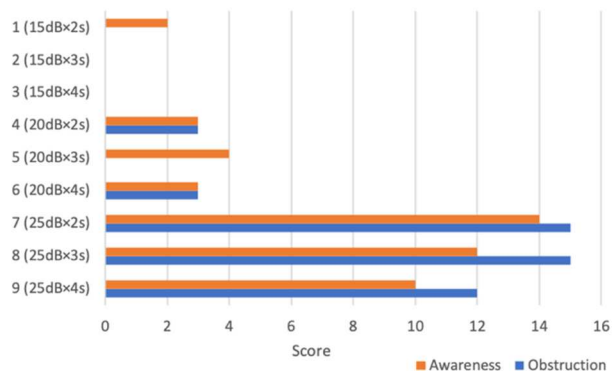


Figure 2. Total scores of the ranked results. We summed up the number of participant's votes for each condition that ranked a condition within their top three, then reported the overall score.

There was no significant difference in the each of duration in sound change, suggesting that the duration of sound change does not have much effect on awareness and obstruction. Therefore, we conclude that condition 5 had the best notification parameters, since it provides balance between awareness and obstruction.

### V. USER STUDY

Objective: An important context for using our system is when users are occupied with a task, such as while working, during which they receive various notifications. Therefore, our objective of this study is to investigate usability and user impressions of our ambient notifications approach when compared to standard notifications within the before-mention context of use.

We hired 11 college students (2 female) aged between 21-28 years. The participants reported no hearing impairment, were daily PC users and were familiar with common smartphone notifications.

Our experiment contains two sessions. First, a session that uses ambient-notifications, a volume change of 20dB and 3 seconds. This notification attribute was selected based on the results of the preliminary survey, where such attributes generally had low obtrusiveness but could cognitively alert users. The second session contains general notifications, similar to those found in smartphones. We used a general notification named "Definite", obtained from NotificationSounds<sup>1</sup>, which were chosen since it resembled a common notification sound of messaging apps used by most of the participants.

In both sessions, the main task was to complete a 2-minute typing game while receiving the notifications. The typing game was created as a web application that runs in a browser by Vue.js. The game requires participants to type 30 English words as fast as they could (Figure 4). Notifications were

<sup>1</sup> <https://notificationsounds.com/>

executed about five times within each session, which depended on how fast each participant finished the game.

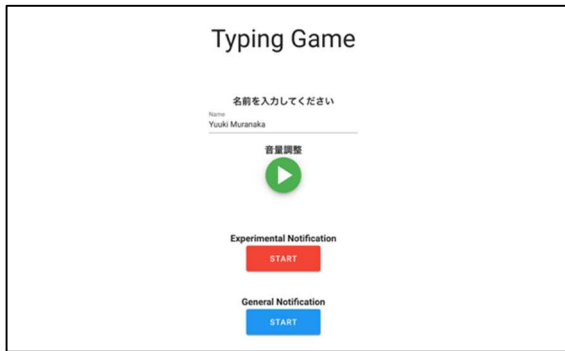


Figure 3. Start scene.



Figure 4. Game play scene of our system.

Participants started the study by wearing headphones, sitting in front of the PC and entering their names (Figure 3, Figure 5). Then, participants were instructed to adjust the volume to their liking, and to start one of the two sessions, where the session-selection was randomized to avoid potential learning-effect. After the two sessions, the participants were given a survey comprised of 14 questions (1 to 5 Likert scale, 5 means agree/yes). The survey was created based on the System Usability Scale (SUS) [13], with extended questions to further study user impressions related to our approach (Figure 6).



Figure 5. This experiment in progress.

## VI. RESULTS AND ANALYSIS

Figure 6 shows the mean scores for each question in our survey. The average score of SUS is 76.8. According to [14], the standard mean of the SUS scores was 68, and the scores in this experiment fell into the category of "good". The usability of the experimental notification is found to be acceptable in terms of effectiveness, efficiency, and satisfaction.

Figure 6 shows the average scores for each question in our own questionnaire. In Q11 ( $\bar{m}=3.4$ ,  $SD=1.07$ ), we investigated the obstruction of concentration in notifications by changes in sound volume. Participants indicated that it was easy to concentrate because the notifications were part of the ambient music. However, some of the participants said that the volume changes were distracting. This may have been due unfamiliarity with our approach.

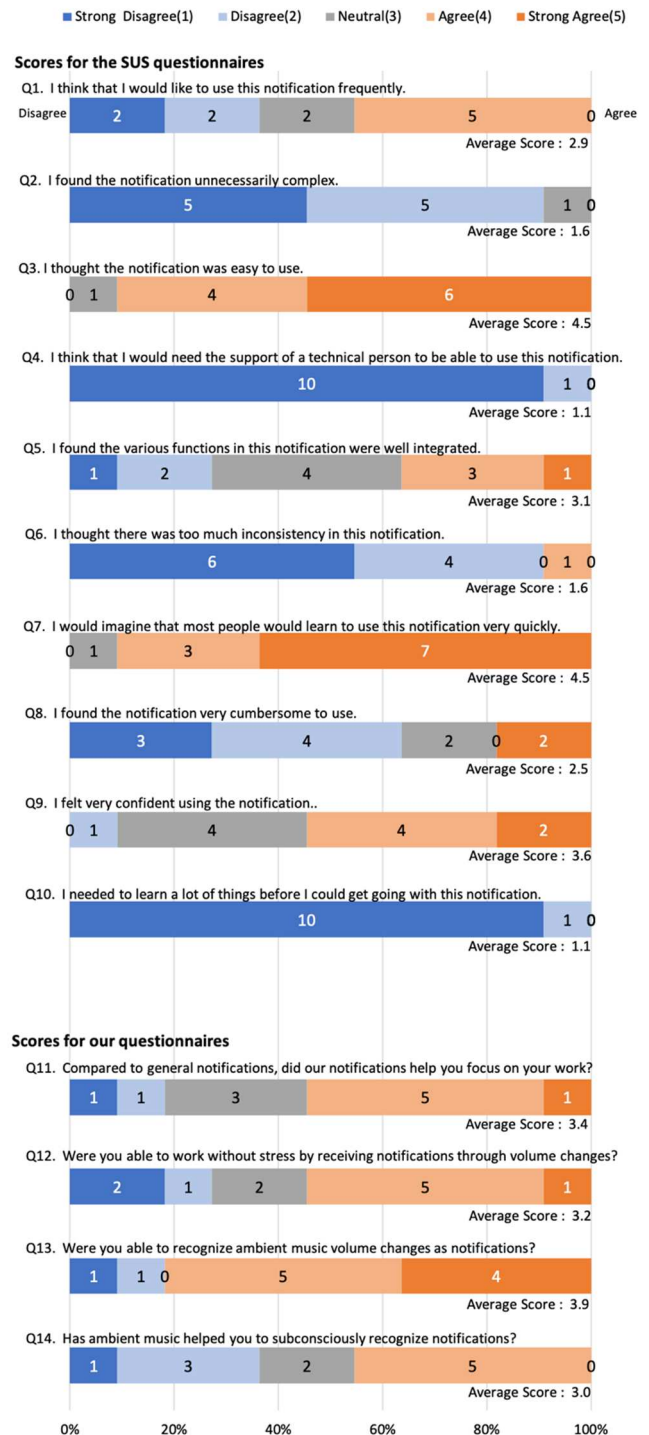


Figure 6. Survey questions and scores.

In Q12 ( $\bar{m}=3.2$ ,  $SD=1.27$ ), we investigated the stress of notifications due to changes in sound volume. Participants stated that the experimental notifications were less stressful than the general notifications as the changes were more

gradual and did not disrupt the mood of the music. Participants also mentioned some challenges. First, they mentioned that listening to loud music was sometimes stressful. Since there are individual user-preferences for volume levels, it is critical to provide notifications with volume changes that match user preferences.

In Q13 ( $\bar{m}=3.9$ ,  $SD=1.24$ ), we investigated the cognitive effects of notifications caused by changes in the volume of ambient music. Most of the participants answered that they could recognize the notifications in ambient music. Specifically, participants thought it was easy to recognize notifications; since there were not any volume-changes in the played ambient-music, any changes were easily detectable.

In addition, since all of the participants typed on a daily basis, they were able to complete the task easily. This aspect has reflected on the recognizability of notifications, as we believe it contributed to better recognize ability of notifications based on ambient music. This finding is supported with feedback from some participants, who mentioned they did not know if they would be able to recognize the notification if the task was more engaging and required deeper concentration or more attention. Therefore, we believe it is essential to investigate recognizability of our notifications under different types of tasks and different mental loads.

In Q14 ( $\bar{m}=3.0$ ,  $SD=1.04$ ), we investigated the change in awareness of ambient music volume change notification. Participants thought that they were able to recognize the notifications in a more natural way, which indicate that the notifications did not largely interfere with their concentration on the task. However, participants also noted that notifications were not always enforceable; when engaged in the task, the notifications sometimes were not enough for users to pay attention to, and so they were sometimes unnoticeable by users. Therefore, using more drastic notification attributes, such as sudden or large changes in volume, might be needed in order to ensure drawing a user's attention to important notifications.

We believe the results are overall positive and encouraging to pursue further work. The results show that ambient music notifications could lead to more natural notification recognition. However, there exist some challenges as some users could not easily distinguish notifications when they were more engaged in the task. Also, our results indicated there exist individual preferences for the volume levels of the notifications. Therefore, future work should investigate more varied attributes and individualized of ambient music based notifications.

## VII. CONCLUSIONS AND FUTURE WORK

This work investigated a novel approach exploiting ambient music as a mean to convey unobtrusive notifications. Using the "unconscious listening" aspect of ambient music, we proposed a method of notifying users by locally changing the volume of music while focused on various tasks. We conducted a usability study comparing notifications based on ambient-music with general notifications. The results show that most of the participants were able to recognize the proposed notification method without being distracted from

the task, unlike general notification methods that were more distracting.

Notifications based on ambient-music had additional advantages as they were less disruptive and highly preferred over regular notification sounds. However, some of the participants felt discomfort or were distracted as such notification methods were unfamiliar to them. Another challenge was that important notifications could go unnoticed under the currently used notification attributes. Accordingly, future work should investigate methods to ensure alerting users about important notifications. One direction is to study notifications with largely varied sound attributes, such as large volume changes. Another direction is to explore musical elements, such as changes in pitch or playback speed. In order to successfully design notifications based on ambient music, we believe it is essential for future work to evaluate and understand the effect mentioned notification-attributes under varied task types and mental loads.

## REFERENCES

- [1] Alireza Sahami Shirazi, Niels Henze, Tilman Dingler, Martin Pielot, Dominik Weber, Albrecht Schmidt, "Large-scale assessment of mobile notifications", Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, April 2014
- [2] SungHyuk Yoon, Sang-su Lee, Jae-myung Lee, KunPyo Lee, "Understanding notification stress of smartphone messenger app", Extended Abstracts on Human Factors in Computing Systems, April 2014
- [3] Rahul Rajan, Ted Selker, Ian Lane, "Effect of Mediating Notifications Based on Task Load", Proceedings of the 8<sup>th</sup> International Conference on Automotive User Interfaces and Interactive Vehicular Applications, October 2016
- [4] Fulvio Corno, Luigi De Russis, Teodoro Montanaro, "A context and user aware smart notification system", Proceeding of the 2015 IEEE 2nd World Forum on Internet of Things, December 2015
- [5] Ed Cutrell, Mary Czerwinski, Eric Horvitz, "Notification, Disruption, and Memory: Effects of Messaging Interruptions on Memory and Performance", INTERACT2001, January 2001
- [6] Stavros Garzonis, Simon Jones, Tim Jay, Eamonn O'Neill, "Auditory icon and earcon mobile service notifications: intuitiveness, learnability, memorability and preference", Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, April 2009
- [7] Fu-Yin Cherng, Wen-Chieh Lin, Jung-Tai King, Yi-Chen Lee, "Understanding the Influence of Musical Parameters on Cognitive Responses of Audio Notifications", Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems, April 2018
- [8] Adam J. Lonsdale, Adrian C. North, "Why do we listen to music? A uses and gratifications analysis", British Journal of Psychology, February 2011
- [9] Xiao Hu, Fanjie Li, Runzhi Kong, "Can Background Music Facilitate Learning?: Preliminary Results on Reading Comprehension", Proceedings of the 9th International Conference on Learning Analytics & Knowledge, March 2019
- [10] Rong-Hwa Huang, Yi-Nuo Shih, "Effects of background music on concentration of workers", Work, January 2011
- [11] Hyperreal Music Archive Info, "Music for Airports liner notes", [http://music.hyperreal.org/artists/brian\\_eno/MFA-txt.html](http://music.hyperreal.org/artists/brian_eno/MFA-txt.html), [Nov. 2020]
- [12] Ravi Mehta, Rui (Juliet) Zhu, Amar Cheema, "Is Noise Always Bad? Exploring the Effects of Ambient Noise on Creative Cognition", Journal of Consumer Research, December 2012
- [13] J. Brooke, "SUS : A quick and dirty usability scale", Taylor & Francis, Usability Evaluation in Industry, pp.189-194, 1996.
- [14] A. Bangor, P. Kortum, and J. Miller, "Determining what individual SUS scores mean: adding an adjective rating scale", Journal of Usability Studies, vol. 4, Issue. 3, pp.114-123, May 2009