The recognition and disturbance of notification sounds integrated into the music

Media Technology

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Abstract. Notification sounds can have a disturbing effect. This research is focused on placing notifications in different contexts to measure its recognizability and disturbance. Three different contexts are evaluated: a notification sound played on its own, a notification sound combined with background sound and a notification sound integrated into the music. We have performed two experiments, each with different test subjects. The first experiment tests the recognizability of a notification sound integrated into the music. The second experiment tests the disturbance of a notification sound in the three different contexts during calculation tasks. By doing this, participants peripherally recognize the notification sound. Notification sounds integrated into music were recognizable. They were perceived as less disturbing compared to notification sounds played on their own or combined with background sound.

Keywords: notification sounds, disturbance, recognizability, music

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1 Introduction

The continuous information stream from a phone can be a real distractor. Some studies have found a negative impact of mobile phones on someone's well-being. One impact that mobile phones might have is the occurrence of social network fatigue (Ravindran et al., 2014). This means that a user can experience fatigue by the social interactions, the content of social media, or the need to stay socially connected.

Another impact that mobile phones can have is the effect on the attention and mental workload. When people receive notification sounds, it can disrupt people from their current task. Receiving notifications and interacting with them can lead to performance issues, such as scoring lower on tasks. According to Stothart (2015), visual notifications can have an impact on the performance of a task even by not interacting with it. It can also induce mind wandering, which can last much longer than the notification itself.

However, in comparison to visual notifications, audio notifications would be "much less obtrusive than visually showing an appropriate representation" (Chernyshov, 2016, p.1). When communicating simple data, it can be logical to use audio notifications, as audio cues can be perceived in a more peripheral way (Jung et al., 2007). This means that the notification can still be noticed while performing another task. To illustrate, a car creates certain noises while driving. Normally, this sound is not too noticeable, unless you pay attention to it. When this sound suddenly changes, the sound is perceived immediately.

The problem of receiving notifications is how it can disturb a person during the performance of a task. What would be interesting to research, if notifications can be created in such a manner that would be less disturbing. Our idea for this research is if notification sound can be integrated into music to make them less disturbing. Findings show that music does not have a profound effect on the performance of a task. According to research by Pool et al. (2003), music and music videos have no large effect as a distraction during studying and have little effect on task performance. Motivated cognition can be used for explanation. This means that people have the motivation to direct their attention away from music, thus limiting their attention to music. This is especially the case when music has been used habitually while multitasking (David et al., 2015).

Additionally, while music has been found to have little effect on the performance of tasks, people are still able to detect changes in sound. According to Fastl et al. (2006), people can interact with a complex, mentally demanding task and still be able to detect changes in sound.

In this research, notification sounds are integrated into music and it will be tested if this has any effect on perceived disturbance. To substantiate, a theoretical framework is made. First of all, a distinction between music and notification sounds is made. A few definitions of music are discussed and the definition of different types of notification sounds (earcons and auditory icons) is described. This is to clarify the difference between notification sounds and music and what definition of both music and notification sounds is used in this research.

After this, the perception of music by people is discussed, how people group musical patterns, and whether speech can be perceived as music. This is to gain insight into how humans perceive music, and this knowledge can be used for integrating notification sounds into music. After this, different types of learning are discussed and theories about attention are discussed. Learning and attention play a role in the experiment which makes it useful to discuss. At last, related work is discussed.

1.1 The distinction between music and notification sounds

As mentioned before, the distinction between music and notification sounds is discussed. Music can have many different forms and has a broad definition. Thus, to make clear what falls under the category of music, the term 'music' should be defined in this research. It is also discussed whether notification sounds fall under the category of music.

One definition of music can be:

"Unwanted sound is noise. Music is humanly organised sound, organised with intent into a recognisable aesthetic entity as a musical communication directed from a maker to a known or unforeseen listener, publicly through the medium of a performer, or privately by a performer as listener."(Godt, 2005, p.84)

This definition assumes that music is at least organized in a certain way. Random notes or noise would not be considered as music. Additionally, the definition states that music is intended to be seen as an aesthetic entity. This means that the created sound has the intention to be pleasing. Furthermore, musical communication is being established. This means that the composer conveys a message via communication in an understandable language. The composition is the form of communication and the language is the style of the music and has a certain grammar.

Notification sounds do not have particular means of being an aesthetic entity, although it forms a certain communication. The main intent is to inform the user of an incoming message. Thus, according to this definition, notification sounds do not fall into the category of music.

Another definition of music can be as follows:

"sounds temporally organized by a person for the purpose of enriching or intensifying experience through active engagement (e.g., listening, dancing, performing) with the sounds regarded primarily, or in significant measure, as sounds" (Levinson, 2011)

This definition regards music as an art form with engagement from the listener. Solely, the sound is not regarded as music. It must have the intention to engage with the public. Thus, it can be concluded that notification sounds are not considered as music, as the purpose is not to enrich the experience through active engagement.

In the scope of this research, the definition of music consists of active engagement of the public combined with a composer who communicates via musical communication. Additionally, it is important to distinguish between music and a notification sound. The content itself can be the same, although the function differs. The music consists of the active engagement of the public combined with a composer who communicates via musical communication. Notification sounds have the function to inform the user about a new message, while music has the overall function to be enjoyed (i.e. being an aesthetic entity) with a form of communication.

1.2 Definition notification sounds

In the section before, the definition of music was discussed, and it was investigated whether notification sounds can be placed into the category music. As can be seen, there is a difference between notification sounds and music. In the following section, the definition of various types of notification sounds is described: earcons and auditory icons. This is to clarify what definition is used for a notification sound in this research.

Earcons
Notification sounds can be divided into two categories: earcons and auditory icons. Earcons are "*non-verbal audio messages used in the user-computer interface to provide information to the user about some computer object, operation or interaction*" (Blattner et al., 1989).

Another definition: "*Earcons are abstract, synthetic tones that can be used in structured combinations to create sound messages to represent parts of an interface*", "*composed of motives, which are short, rhythmic sequences of pitches with variable intensity, timbre and register*" (Brewster et al., 1993).

For example, a sound can be played when opening a file on a computer. Another example is a notification sound. The audio message is used to provide information about a new message. Earcons provide great flexibility and can be designed in families which has a hierarchical structure (Garzonis, 2009). For example, different items in the same dropdown menu could have a similar type of sounds, i.e. using different piano sounds.

However, one drawback is that these earcons do not have a clear relationship with their referent. The object a sound is referring to is arbitrary (i.e. a piano sound does not have any relationship with pressing a menu button). Therefore, it can be more difficult for people to memorize these relationships.

Auditory icons
The other category of notification sounds is auditory icons. Auditory icons often have metaphors to link to their referents. When a good mapping is utilized, the icons are more easily remembered. For example, the sound of a slamming door can be used when the user turns off the computer. The kind of mappings leads to a lack of flexibility because mappings are more difficult to find. Also, these sounds can be confused with actual environmental sounds (Garzonis et al., 2009).

In this research, a notification sound is an earcon because the notification sound does not have a relationship to the object it is referred to. However, in this research, the notification sound does not yet refer to any object, as the disturbance and recognition of notifications of only the sound are measured. In a real-life setting, the notification would have an object to refer to.

1.3 Aspects of musical perception

In this section, it is described how music is perceived by people. This can be useful to describe because music is used in this research. The knowledge about how music is perceived by people can also be used as an inspiration to better integrate notifications into music.

Quite often, familiarity plays a large role in popular music. This has to do with the fact that we all create certain "schemas" (Tervaniemi, 2004). Schemas are based on previous stimuli and are a cognitive representation of "music". In other words, it is the idea of placing sounds into different categories. Some sound samples belong to the category 'music' and others do not. Overall, music consists of tuning, keys, and tonality. When listening to music (= current stimuli), it is compared to previously known stimuli.

According to research by Tervaniemi (2004), the incoming sounds are more efficiently processed when it matches the template of our schema. This is also called "musical memory" which is processed in the auditory cortex of the brain.

Speech and music
One interesting aspect of musical perception is that speech often is not categorized as music in our brains. Although speech consists of sound with different pitches, it is often not categorized as music because the spoken phrases do not match the template of music. However, research by Deutsch (2011) shows this is not always the case. If a spoken phrase is repeated, participants can perceive it as music.

An explanation for this is previous music knowledge. If the repetitive spoken phrases conform to the idea of music by the receiver, for example, with familiar scales and pitch information, it can be perceived as music (Deutsch, 2011).

Although notifications by themselves are not considered music, they can be perceived as music when they conform to the template of music. Therefore, logically combining notifications with music should let people perceive notifications as part of the music. This means the notifications become a part of the music and become integrated with music.

Gestalt

Additionally, when integrating notifications into music, it can be useful to investigate how musical patterns are being grouped by people. To integrate notifications into music, it is important to make sure that the notification sound is perceived in the same group as the musical patterns in the song.

The grouping of auditory patterns is part of auditory perception. The concept of Gestalt was first developed by Ehrenfels (1890). It states that the sum of incoming sensory parts is more than its parts. For example, a melody is often perceived as more than just individual notes.

Even more famous are the Gestalt laws, which were introduced by Wertheimer (1923). These laws describe how patterns are being grouped and can be either visual or auditory. Humans tend to perceive whole patterns instead of just individual components. Note that Gestalt is merely a theory and not necessarily based on knowledge (Wertheimer, 1923). In the bullet points below, six different Gestalt principles are discussed. These Gestalt principles are useful for integrating notifications into music.

- According to the Gestalt principle “proximity”, humans tend to group nearby patterns together
- Another Gestalt principle is called ‘similarity’. This is the tendency to group similar sounds.
- The third Gestalt principle is called “good continuation”. This means that sounds that follow each other in a certain pattern, are grouped.
- The fourth Gestalt principle is “common fate” which means that sounds that are changed in the same manner are perceptually grouped.
- The fifth Gestalt principle is “closure”: this means that the brain adds elements that are missing. Thus, if a certain song has a certain melody and a few notes are being omitted from the melody, then the brain will “add” the notes to complete the melody.
- The sixth Gestalt principle is “symmetry” which means that items that are more symmetrical to each other are more likely to be perceived as part of the same group. In a paper by Jung (2007), symmetry is described as the principle that similar sounding sounds or patterns are grouped even though these patterns can be far apart from each other. If the same pattern is played in another part of the song, it can be recognized by the listener.

1.4 Learning

In this research, learning plays an important role, because notifications will be learned in the research. Participants need to memorize these notifications and recall them at a later stage. Both implicit learning and explicit learning takes place in the experiment. Furthermore, the learning curve could influence some of the scores in the experiment as participants hear the same notification repetitively.

Learning curve

The learning curve was first described by Ebbinghaus (1885) in his book “Über das gedächtnis”. The learning curve describes how fast someone learns information and is an exponential curve. In the beginning, someone learns information quite fast. Over time, the amount of new information that can be learned and retained decreases. A learning curve can also be described for someone performing a task.

It is said that someone can become more efficient in a task when he is performing this task more frequently.

Implicit learning
For experiment 1, implicit learning can influence the scores, therefore it is important to know the definition of implicit learning.

Generally, implicit learning can be described as acquiring new knowledge without any conscious awareness. Often, learners cannot explicitly explain what they have learned (Ellis, 1994). However, to give a more precise definition of implicit learning, we can refer to the research by Seger (1994). According to Seger, three different criteria (and one additional guideline) needs to be fulfilled for something to be considered as implicit learning.

"The first criterion is that the knowledge gained in implicit learning is not fully accessible to consciousness, in that subjects cannot provide a full (or, in many cases, any) verbal account of what they have learned."

"The second criterion is that subjects learn information that is more complex than a single simple association or frequency count."

"The third criterion is that implicit learning does not involve processes of conscious hypothesis testing but is an incidental consequence of the type and amount of cognitive processing performed on the stimuli"

"In addition to these criteria, as a guideline, implicit learning is preserved in cases of amnesia. Thus, implicit learning must rely on neural mechanisms other than the hippocampal memory system" (Seger, 1994, p. 164)

Explicit learning
Generally, the difference between implicit learning and explicit learning is mostly on conscious awareness. Explicit learning happens consciously. The working memory is greatly utilized in explicit learning in comparison to implicit learning.

1.5 Attention and peripheral interaction

In this research, attention plays a role in the experiment (i.e. when recognizing a notification). During one of the experiments, participants must do multiple tasks at the same time. Therefore, it can be useful to learn about how attention works in the human brain and what types of attention exists.

One of the early theories about attention is the bottleneck theory (Broadbent, 1958). This theory states that from all incoming information a small amount is selected and only this part can be processed in the brain. Another theory is the divided attention theory (Kahneman, 1973). The theory states that a certain amount of resources is available, and these resources are divided among different activities. For example, when multitasking (multiple activities at the same time), the attention is divided among these activities.

Another type of attention is selective attention and has to do with becoming aware of incoming stimuli. One famous example of this is the cocktail party effect (Cherry, 1953). While being at a party and having a conversation with someone, your attention is focused on the conversation. Other sensory information has been filtered out. However, when someone else (not in the conversation) mentions your name, it is still possible to notice your name. This can principle also appears in this research. A person can be trained to recognize a notification when it is integrated into the music. According to the cocktail party effect, during conversions, the person should still be able to recognize the notification. Accordingly, during a task, this person should also be able to recognize the notification.

Stressors are stimuli that cause stress and can have an influence on attention while performing a task. Notification sounds can fall into this category. In an era in which computers are ubiquitous, it is important to make sure its users do not become too overwhelmed or stressed. Weiser et al. (1997) propose a technology called ‘calm technology’ and describe it as “technology that engages both the center and periphery of our attention and in fact, moves back and forth between the two” (Weiser et al. 1997). This means that one activity is in the center of our attention, while multiple activities can be in the background (or periphery) of our attention, with the possibility to shift focus between them.

According to Bakker et al. (2016), three different types of interaction exist. The first one has focused interaction, which means that the center of attention is focused on a certain task. This attention is conscious and intentional. This interaction takes the most mental resources. The second one is implicit interaction, which happens in the subconscious mind and is unintentional. Only a few mental resources are needed. The third one is peripheral interaction, which is in the middle of the two and is subconscious and intentional. In this research, peripheral interaction takes place when a person does a task and hear notification sounds at the same time.

1.6 Related work

A few studies focus on creating notifications to make them more pleasant or to integrate them with music (Butz, 2005). Notification sounds consist of a short musical phrase using a few musical notes. In this manner, people were able to receive notifications without the disturbance of others. Another research from Jung (2007), created a notification application that can be used by multiple people. The sounds were integrated into the music and different people would be able to distinguish their notification sound from the music.

In one research (Jung et al., 2005), sounds with acoustic instruments (such as piano and drums) were used as a notification. The participants learned the notification beforehand. They were then asked to identify their notification sound within a piece of music. It was concluded that drums (i.e. rhythm-oriented instruments) were easier to identify than instruments with melody, such as the piano.

All in all, these studies have shown that it is possible to create a system in which different notification sounds are implemented into music. These notification sounds can be recognized, while other people are not disturbed. Ambient soundscapes were used in which notifications were embedded. However, what would be interesting to research, if it is also possible to integrate notification sounds in different types of genres and not just ambient soundscapes. This means the notifications can be integrated into nowadays popular music as well. Our research investigates whether it is possible to create such notifications and make them recognizable and less disturbing at the same time.

Furthermore, it is not yet researched whether the perceived disturbance of these notifications is lower than other types of notifications. Our study investigates if this is the case and compares notifications integrated into music with notifications in different contexts (background sound or silence).

Alternative approaches for creating less disturbing notifications can be found in the literature. Other related research (Chernyshov et al., 2016) focused on continuous information rather than binary information. Progress was shown instead of a single notification sound. Arbitrary audio samples were used as sound icons. The process was mapped to the sound sample and the rhythm changed based on the process. Pitch was not used for a change in the process, because it would affect the sound samples in such a manner that they would become unrecognizable. In the research, six different priority levels were used for the processes (0-5). The detection rate was 92.44%.

Brown et al. (2015) used a typing test while playing notification sounds (ABC ringtones). ABC ringtones are ringtones based on ‘familiar and personally relevant sounds and words’ (Brown et al, 2015, p.2). The loudness of the sounds varied between soft, medium, and loud. The different ringtones were: “participant’s normal ringtone, the voice of a loved one saying a low-valence word, the voice of a loved one saying the participant’s name, a stranger’s ringtone and the voice of a stranger saying the participant’s name.” The task performance was measured. The ABC ringtones had a response in the brain even though the volume was too low to be heard consciously. The embedded information was perceived even though the ringtones did not disturb them from the task.

2 Research approach

As previous research showed, notifications can be perceived as disturbing. It would be interesting to research the possibility to create notifications that are recognizable, but at the same time less disturbing. A logical reason would be to use audio notifications, as they are found to be less obtrusive in comparison to visual notification (Chernyshov, 2016). An additional advantage of using sound is the fact that when people interact with a complex task, they are still able to detect changes in sound (Fastl et al., 2006).

Furthermore, music would be considered less distracting (Pool et al., 2003). As can be seen in the theoretical framework, a notification is not considered to be music. It would be interesting to combine both notifications and music to measure if the combination influences its perceived disturbance. Thus, we have decided to integrate notification sounds into music and to test whether the notification sounds are recognizable, but at the same time perceived as less disturbing.

As can be seen from previous work, research has shown that notifications can be blended into music. What is not yet covered, is to test the disturbance of notification sounds when notification sounds are integrated into music in comparison to notifications combined with background noise, or silence. Also, no research integrates notification in different types of genres.

Please note that this research is focused on the disturbance of a sound notification and not on its message. In real life, the message behind a notification can cause extra disturbance (e.g. when the message is important and immediate response is required). Also, the notification is meant for the person himself and not for another person.

This research would then come down to answering the following research question:

Q: Can integrating notification sounds in music make the notifications less disturbing?

To answer the research question, two different aspects will be measured in this research. The first experiment tests the recognizability of notification sounds when they are integrated into the music. Thus, it leads to the following sub-question:

Q1: How recognizable are notification sounds when they are integrated into music?

The hypothesis that will be tested during the experiment is as follows:

H: Notification sounds integrated into music are less recognizable if the listener does not know what the notification sound is

The second experiment tests the perceived disturbance of notification sounds when they are either integrated into music or presented in combination with background noise or a silent context. The disturbance during a task is measured.

This leads to the following sub-questions:

Q2: How disturbing are notification sounds while performing a task when integrated into music compared to a notification sound played on its own?

Q3: How disturbing are notification sounds while performing a task when integrated into music compared to a notification sound combined with background sound?

3 Method for experiment 1

Two different experiments are created. The first experiment tests the recognition of notification sounds integrated into music and the second experiment tests the disturbance of notifications sound in three different contexts: integrated into the music, combined with background sound or silence. In this chapter, the method of the first experiment is discussed, in Chapter 4 the results of the first experiment are discussed. Chapter 5 describes the method for the second experiment and Chapter 6 describes the results of the second experiment.

1. Subjects

The first questionnaire had a total number of 52 participants. However, participants who completed less than 90 percent were excluded from the analysis. Participants who finished too quickly were also excluded. This led to a total of 30 remaining participants.

Participants were asked via WhatsApp, Facebook, Email, and other social media. The demographic attributes were not asked as there was no specific target audience for the experiment. Moreover, those variables were not expected to influence the results.

2. Stimulus patterns and procedure

Creation of sound samples

To research the recognizability of notification sounds integrated into the music we have created three different notification sounds that have each been integrated into 12 different pieces of music. Together this leads to 36 different sound samples, from which a selection is made to be used in the experiments. Each sound sample has a duration of 19 seconds. The notification consists of short phrases from synthesized instruments. The midi instruments used are piano, bansuri flute, and celesta. Twelve musical fragments were used and consist of different genres. The notifications are earcons as there was no metaphor for a referent.

Explanation of the experiment

The first experiment has been developed to answer the first research question (see Research approach). We will use the above-mentioned samples in which the three different notification sounds have been integrated into the different musical fragments. This experiment is structured into five parts (see Table 1). The pre-test contains questions about music, distraction, and mobile phone notifications (see Appendix A). Test 1.1, the training phase, and Test 1.2 are now explained.

First, we would like to know whether the integrated notifications are recognizable when you do not know (yet) how they sound. Ten different samples of 19 seconds each are played. For each sample, the participants need to judge whether a notification sound is present in the presented musical fragment. We call this Test 1.1.

After this phase, a training phase takes place. The participants learn how the three different types of notification sounds sound. In the third phase (Test 1.2), the same sound samples are used from Test 1.1, and participants are asked again whether these musical fragments contain one or more notification sounds. The reasoning behind this structure is to test whether the notification sounds can be recognized without learning the notification sound beforehand and to test whether more (or all) notification sounds can be recognized after learning the notification sounds.

The last part is the posttest with additional questions. Participants are asked if they find notifications integrated into music recognizable and less disturbing.

An overview of the first experiment can be found in Table 1. Please note that these music samples are the same for every participant. The order of these music samples is also the same. Of the ten different music samples, two of them contain no notification sound. When adding too many sound samples without a notification sound, not enough sound samples can be compared to each other and it is more difficult to get results. In Appendix B can be seen which notification sounds are used and which music samples.

Four questions are asked per music sample. The questions ask whether the participants recognize a notification sound and when; whether this notification sound is recognizable and whether the notification sound is integrated into the music.

To view the actual questions in the experiment, see Appendix A.

Pre-test	13 Likert-scale questions	Questions about music, distraction, and mobile phone notifications
Test 1.1	10 different music samples	10 * 4 questions
Training phase	3 different notification sounds	5 questions
Test 1.2	10 different music samples (same sound samples)	10 * 4 questions
Posttest	3 Likert-scale questions	Questions about disturbance and recognition of notifications that are integrated into the music

Table 1. The first part of the experiment -> test the recognizability of notification sounds

Integration of notifications into music

The sounds are integrated into different manners. The first type of integration is to play the notification sound on the first same beat. According to the Gestalt principle of proximity, the same sounds are grouped when played near to each other.

The second type of integration is to play the notification sound in the tempo of the song, but not necessarily on the first beat. The notification sound is played on the second or third beat and is integrated with the rest of the music.

A third method to integrate is to match the schema (Tervaniemi, 2004). People have certain expectations about a song or genre. For example, when jazz is played, often the same combination of instruments is used. When the notification sound matches this template, it is perceived as a better integration.

Notifications are unchanged

The three different notification sounds remain the same in different songs. The reason for keeping the notification sounds the same, is to make the notification sound more recognizable. The tempo or key of the notification sound could have been changed, but we decided to leave the notification sound the same. In research by Chernyshov (2016), it was chosen not to change the pitch. In the research, notification sounds represent continuous information instead of binary information. *"Even a slight pitch change of a sample may change it to a degree where users can not recognize it or associate it with the process it represents."* (Chernyshov, 2016). It would be harder to notice the notification sound, especially when doing a task (as would be in the second experiment). This does also mean that some notifications are better integrated into the song because it might match the tempo or key better. The goal is to create different sound samples with different levels of integratedness. The participants need to evaluate by themselves whether it is more integrated or not. They are also asked to evaluate which notification sounds are more distracting and which ones are more recognizable.

Another reason for not changing the notification sound is because the notification sound in an everyday situation is likely not going to change. Thus, it would represent a real-life situation better.

Learning curve and attention
In the experiment, a learning curve exists. Over time, participants learn the three different notification sounds and the expectation is that participants will be better at recognizing the notification sounds. This could influence the scores of recognizing notification sounds.

Furthermore, attention plays a role in the experiment. The participants are asked to conduct the experiment in a silent room as this might influence the attention of the participant.

3. Instrumentation and software

The software used to create the questionnaire is Qualtrics. The participants are asked to conduct the experiment in a silent room with either earbuds or headphones.

Creation of sound samples
The sound samples are created with Cubasis. The songs and background sound samples are from https://freemusicarchive.org/ and https://freesound.org/ (for more details see Appendix B). The notification sounds are created with midi instruments. The first notification sound is created with piano (Cubasis stock sound), the second one is created with Bansuri flute (Noise melody), and the third one with celesta (Cubasis stock sound). There was no difference between priority levels and no difference has been made on the loudness of the notification sound. All sound samples are made to have the same loudness.

Analysis of the data
Three different programs are used for data analysis. The most used program is R studio. This is used for both data cleaning and data analysis. The data cleaning is necessary, as some questions contained Likert scales with values 1-5 and other questions had values 8-12. Medians and IQR were calculated in R studio, as well as Spearman correlation and Wilcoxon signed-rank test. The second program used is Excel, for data cleaning. This data cleanup was mostly to select the most important columns and give the columns easily recognizable names. This makes it much easier to analyze the data. The last program used is JASP for data analysis. The statistical tests done in JASP for experiment 1 are not included in this paper as they were for inspiration and not necessary.

4 Results for experiment 1

The average duration to complete the first experiment is 22.3 minutes. A few participants completed the questionnaire in more than 167 minutes, which probably means they left the questionnaire and came back later. These are considered outliers and were not included in the average duration.

1. Pretest analysis

At first, the pretest questionnaire was analyzed. The questions can be found in Appendix A.
The questions below were answered by using a Likert scale. The answers participants could give were: Strongly disagree, Somewhat disagree, Neither disagree nor agree, Somewhat agree, Strongly agree. For descriptive analysis, medians were calculated. Number 1 represents the lowest value (Strongly disagree) and number 5 represents the highest value (Strongly agree).

On average, vibrating notification sounds were preferred (45.3%), then visual notifications (35.9%), and then sound notifications (18.8%) (see Appendix C).

Sound notifications
When participants were asked if sound notifications are distracting, they answered that notifications were somewhat distracting. This was the same for receiving an unexpected sound notification themselves (Mdn = 4, IQR = 1) and for someone else receiving a sound notification (Mdn = 4, IQR = 1).

It was also asked whether participants found sound notifications distracting during tasks. Participants found that when a task requires little mental effort, sound notifications are not very distracting (Mdn = 3, IQR = 2). For tasks that require a lot of mental effort, sound notifications are definitively distracting (Mdn = 5, IQR = 1).

Music
For the question of how many hours participants listen to music, participants would say 2-4 hours per day (Mdn = 2-4 hours, IQR = 1). For the question of whether the type of genre would influence the disturbance of music, participants would say Strongly agree (Mdn = 5, IQR = 1). When asked to describe if they find their taste in music diverse, they would somewhat agree. (Mdn = 4, IQR = 1).

Participants answered they would sometimes listen to music when performing tasks. For little mental effort tasks, music is played more often (Mdn = 4.5, IQR = 1) and for tasks requiring a lot of mental effort, music is played less often (Mdn = 3.5, IQR = 2.75). Music is perceived as not distractive when people are performing a task that requires little mental effort (Mdn = 1, IQR = 1). If a task requires a lot of mental effort, it is a bit distractive (Mdn = 4, IQR = 2). (for more details, see Appendix B, C, and D)

2. Test 1 analysis

After hearing each sound sample, the participant was asked whether a notification sound was played and when. It was considered a correct answer when a notification sound was recognized within a margin of 8 seconds (4 seconds before and 4 seconds after the notification). Questions 1 and 5 did not contain any notification sound, thus the correct answer would be to not recognize any notification sound at all. As can be seen in Figure 1, Q4, Q5, Q8, and Q9 were easy to recognize even before training (above 85% correct).

Overall, 72% of the notification sounds before the training phase were correctly recognized, 81% after the training phase were correctly recognized.

When comparing the different questions, Q3 (40%) and Q6 (50%) scored the lowest before the training phase. Q3 did improve a bit after training (56%) and Q6 improved dramatically after training (76%). Q7 improved as well, from 63% to 80% correctly recognizing the notification sound.

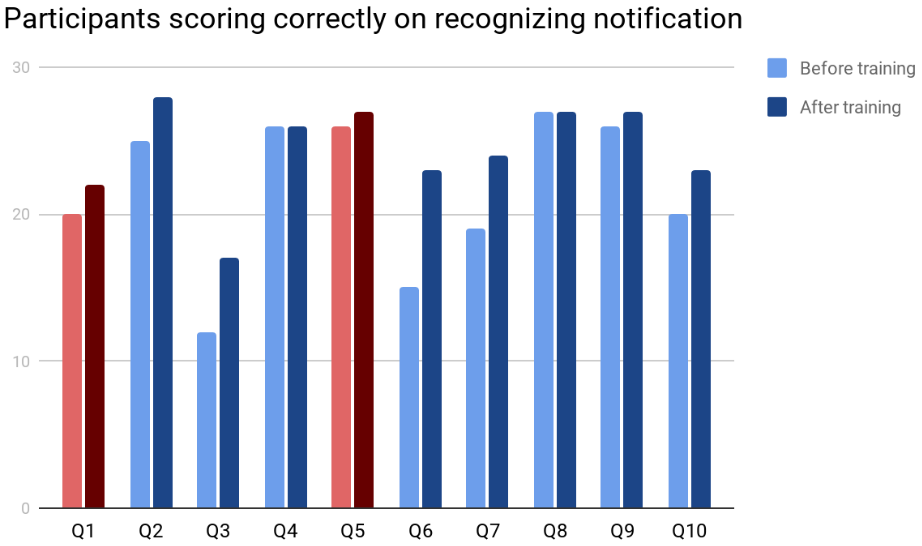

Figure 1. Number of participants recognizing notification correctly

Notification sounds

According to participants, all three notifications are recognizable. The first notification, participants would say it is somewhat recognizable (Mdn = 4, IQR = 1), second notification is also somewhat recognizable (Mdn = 4, IQR = 2), as well as the third notification sound (Mdn = 4, IQR = 1). For the disturbance, most people would say they have no opinion on the disturbance of the notification sounds (Mdn = 3, IQR = 2).

Overall, most participants preferred the first and second notification sound. The third notification was the least favorite.

Timing of notification sound

The training phase does not influence whether participants guess the timing of the notification sound more correctly. The average mean difference before the training phase is 0.45 and the average mean difference after the training phase is 0.6. For median, the difference is 0.31 before the training phase and 0.38 after the training phase (see also Appendix G, Table 14).

Thus, it would mean after the training phase, participants were less accurate with guessing the timing of the notification sound. A possible explanation for this is that participants become more tired and thus would be paying less attention to the timing of the notification sound.

Recognition

Participants find most notifications in sound samples somewhat recognizable before the training phase (Mdn = 4, IQR = 2). After the training phase, participants found the notifications somewhat recognizable (Mdn = 4, IQR = 1). Thus, the training phase does not affect how people perceive the recognition of the notifications.

Participants find song 9 to be the most recognizable (Mdn = Strongly agree, IQR = 1) before training, after training it is recognizable (Mdn = 4.5, IQR = 1).

Integration

Before the training phase, participants had no real opinion about the integration into the music (Mdn = 3, IQR = 2). After the training phase, they would say notifications are somewhat not integrated (Mdn = 2, IQR = 2).

Questions 8 and 9 were the least integrated before the training phase (Mdn = 2, IQR = 1). Q3, Q6, Q7, and Q10 were most integrated before the training phase. After the training phase, Q3, Q6 were most integrated (Mdn = 4) and Q2, Q4, Q7, Q8, Q9 were least integrated (Mdn = 2)

It seems to be that the type of integration does not influence recognizability. Most songs were somewhat recognizable with different types of integration (Appendix F, Figure 5, and 6).

Correlation between recognition and integration

To measure if there is a correlation between the recognizability of the notification sounds and the integration of notification sounds into music, a Spearman correlation test can be executed.

H_0: *True rho is equal to 0*
H_1: *True rho is not equal to 0*

Results of the Spearman correlation indicated that there was a significant negative correlation between recognizability of the notification sound and integration of the notification sound into music. (R_s = -0.51, $p < 0.05$). This means that the null hypothesis can be rejected, and true rho is not equal to 0. The bubble plot can be found in Appendix H.

3. Training phase analysis

In this experiment, the independent variable is the training phase. The training phase is expected to influence the scores of correctly recognizing a notification. As can be seen in Figure 1, all scores except Q4 and Q8 have been improved. To argue whether this difference is significant, two hypotheses are conducted:

H_0: *There is no difference between scoring correctly on recognizing a notification before the training phase and after the training phase*

H_1: *There is a difference between scoring correctly on recognizing a notification before the training phase and after the training phase*

A Wilcoxon's signed-rank test indicated that the training phase does not have a significant effect on correctly recognizing the notification sound $t(299)=31454$, $p > 0.05$. For further numbers and to see the actual percentages, see Appendix F.

4. Posttest analysis

Most participants somewhat agreed that notifications into music can be less distracting (Mdn = 4, IQR =1). They also somewhat agreed that the notifications integrated into music are recognizable (Mdn = 4, IQR = 1). However, when asked if notifications are equally recognizable when played on its own compared to notification sounds integrated into music, they were slightly disagreeing (Mdn = 2, IQR = 1).

5 Method for experiment 2

1. Subjects

The second questionnaire had a total number of 66 participants. Participants who did not complete more than 90 percent were excluded, as well as participants who finished too quickly. This led to a total of 32 participants. The participants from the first experiment are not the same participants from the second experiment.

2. Stimulus patterns and procedure

The second experiment tests the perceived disturbance of the created notification sounds in different contexts. This time, seventeen questions were asked, and fifteen questions contained a notification sound. The training phase is at the start of the experiment. Participants were asked to guess whether the sound sample contained a notification sound and while doing so, participants were asked to do a calculation task at the same time.

The reason for doing so is to be able to measure whether the integration of notification sounds into music has any effect on the experienced disturbance. To obtain more information, we not only compare the notification sounds integrated into music and (the same) notification sounds played in silence but add a third situation in which the (same) notification sounds are played in a situation with background noise (Table 2).

Three different types of categories will be used.

notification sound without any music or background sound
notification sound with background sound
notification sound with music

Table 2. Three contexts in experiment 2

The main reason for adding the calculation task is to test the perceived disturbance of notifications in different contexts while doing a task. The calculation task would be in the center of our attention, while a notification is in the peripheral of our attention. Often in real life, notifications can have an impact on the performance of a task and can demand more attention than is necessary. We want to measure the perceived disturbance and whether this is different when the notification is placed in different contexts.

In this phase, both music samples and background sounds are used. Six sound samples are combined with music, six sound samples are combined with background sound and three are notification sounds played by themself. Two sound samples do not contain any notification sound. This can be seen in Appendix B.

Four questions are asked per sound sample. These questions ask whether the participant recognizes the notification sound, which notification sound was played, and whether this notification sound was disturbing or integrated into the music.

Furthermore, in Table 3 can be found an overview of the experiment. The actual questions can be found in Appendix A.

Name	Value	Explanation
Pre-test	13 Likert-scale questions	Questions about music, distraction, and mobile phone notifications
Test 2	17 * 4 questions	Calculation tasks and questions about recognizing notification sound
Posttest	3 Likert-scale questions	Questions about disturbance and recognition of notifications that are integrated into the music
Posttest	2 Likert-scale questions	Questions about mental arithmetic

Table 3. Variables/what is measured

3. Instrumentation and software

The same software is used as in experiment 1. The questionnaire is created in Qualtrics and the sound samples are created in Cubasis. The sound samples and their hyperlinks can be found in Appendix B. The background sounds consist of different sounds, such as the sound of a crowd, chickens, or a stream of a river.

Analysis of the data

The same three different programs are used for the data analysis. The most used program is R studio. This is used for both data cleaning and data analysis. Similar to experiment 1, some questions contained Likert scales with values 1-5 and other questions had values 8-12. Medians and IQR were calculated in R studio, as well as Spearman correlation. The second program used is Excel, for data cleaning. This data cleanup was mostly to select the most important columns and give the columns easily recognizable names. This makes it much easier to analyze the data. The last program used is JASP for data analysis. This program is used for the Kruskall-Wallis test.

6 Results for experiment 2

The average duration to complete the second experiment is 20.3 minutes. Two outliers were excluded when calculating the average duration.

6.1 Pretest analysis

The results from the pre-test are described in Chapter 4, Results – part 1.

6.2. Test 2 analysis

Calculation task
On average, 79.5% of the participants answered the calculation task correctly. Questions 3, 5, 6, 7, 9, 10, 11, 12 were scored the best (90% or higher) (see Appendix K).

Some participants scored much lower. Participants 10, 15, 18, and 23 answered ten questions or less correctly. Participant 10 had six correct and ten missing values, participant 15 had nine correct and nine missing values, participant 18 had two correct and six missing values and participant 23 had eight correct and one missing value (Appendix K).

Integration
Participants found question 1, 2 and 13 more integrated (Mdn = 4, IQR = 1; Mdn = 4, IQR = 0.5; Mdn = 4, IQR = 2). Question 9 was the least integrated (Mdn = 1, IQR = 0.25). For disturbance, most participants rated 3 or 4. (Appendix J)

Correlation integration and disturbance
To measure if there is a correlation between the disturbance of the notification sounds and the integration of notification sounds into music, a Spearman correlation test can be executed.

H_0: *True rho is equal to 0*
H_1: *True rho is not equal to 0*

Results of the Spearman correlation indicated that there was a significant negative association between disturbance and integration of notification sounds into music. ($R_s = -0.26$, $p < 0.05$). It means that the true rho is not equal to zero and the null hypothesis can be rejected. The bubble plot can be found in Appendix H.

When each category is split up and compared to each other, it can be found that music has a stronger correlation between integration and disturbance ($R_s = -0.35$, $p < 0.05$) than background sound ($R_s = -0.11$, $p > 0.05$).

Music, background sound, and silence
The three categories (music, background sound, and notification played by itself) will now be compared. The music samples were: Q1, 2, 6, 10, 13, 15, 16; background sound samples were Q4, 5, 7, 9, 11, 12, 17 and the notification samples were Q3, 8, and 14. Q6 and Q12 did not contain any notification sound and are marked in red. The median and interquartile range is calculated for each question.

Q	1	2	6	10	13	15	16	4	5	7	9	11	12	17	3	8	14
Mdn	2	3	4	3	3	3	4	4	4	4	4	4	4	4	4	4	4
IQR	2	2	0	1.5	2	2	1	1	1	1.75	0.25	0	0	1	2	1.25	1

Table 4. Median and IQR for disturbance of sound samples in three categories

The median for music samples is 3, the median for background samples is 4, and the median for sound samples played by itself is 4. Generally, sound notifications combined with music scored lower on disturbance than sound notifications combined with background sound or silence.

Kruskall-Wallis test was used to examine the significant differences between the three categories. The perceived disturbance was significantly affected by the context of the notification sound *H* (2) = 11.731, $p < 0.01$. Pairwise comparisons showed that music has a significant effect on perceived disturbance compared to notification played with background sound ($p < 0.01$) or silence ($p < 0.01$). There was no significant difference between a notification sound that is played with background sound and a notification sound played on its own ($p > 0.01$).

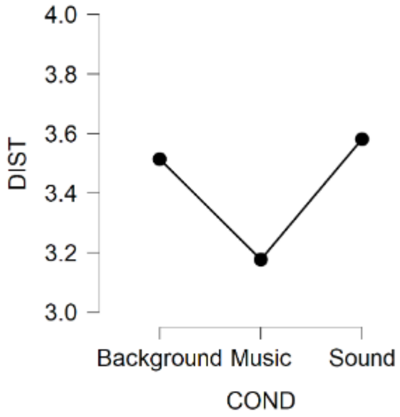

Figure 2. Kruskall-Wallis test

Type of integration

It seems to be that not one type of integration is favorable. Each type of integration seems to give similar results (see Appendix F, Figure 6). What does have an influence, is whether the notification sounds are played during a moment of silence in the song or during other instruments.

6.3 Posttest analysis

Most participants somewhat agreed that notifications into music can be less distracting (Mdn = 4, IQR =1). They also somewhat agreed that the notifications integrated into music are recognizable (Mdn = 4, IQR = 1). However, when asked if notifications are equally recognizable when played on its own compared to notification sounds integrated into the music, they were slightly disagreeing (Mdn = 2, IQR = 1).

For the calculation task, most people found the mental arithmetic quite easy (Mdn = 3.5, IQR = 2) and found the mental arithmetic tasks somewhat doable (Mdn = 4, IQR = 0.5).

7 Discussion

RQ1: *How recognizable are notification sounds when they are integrated into music?*

As can be seen in the result section, notification sounds that are integrated into music are (somewhat) recognizable. However, participants found that notification sounds integrated in music are not equally recognizable compared to a notification sound played on its own. Participants do think the notification sound integrated into music might be less distracting than when it is played on its own.

For experiment 1, the majority of the questions to recognize a notification sound in a music sample were correctly recognized. Most questions scored > 75%, except for Q1 (73%) and Q3 (56%) (Appendix F, Figure 3). The first sound sample is lower, probably because people still need to figure out how to do the tasks in the experiment. Additionally, we can say that the sound sample of Q3 is insufficient. Either the notification is not distinctive enough or it blends too much in the music.

As can be seen in experiment 1, some music samples are more recognizable than others. Participants found Q9 more recognizable, especially before training (Mdn = 5, IQR = 1). Q3 was found to be less recognizable (Mdn = 3.5, IQR = 2). An explanation for this could be that the notification sound in Q9 is played separately from other sounds, while Q3 was played while other instruments were playing at the same time. Q6 had a large increase in the scores of correctly recognizing the notification sound. One explanation for this could be that participants found the notification integrated into the music (Mdn = 4, IQR = 1) and the notification sound seems to be a part of the song. After learning the notification, participants learn how to recognize the notification.

For experiment 2, 82% of the notifications were correctly identified. A few sound samples scored lower. Four out of seventeen questions scored lower than 80%. The first sound sample scored the lowest (34%) (Appendix J, Table 2). The reason for this could be that participants still need to understand how to do the task and need to get used to hearing the notification sound.

Hypothesis: Notification sounds integrated into music are less recognizable if the listener does not know what the notification sound is

This hypothesis cannot be confirmed. For the most part, the notification sounds are already recognizable. The training phase did not have a significant effect on the recognition of the notification sounds.

RQ2*: How disturbing are notification sounds while performing a task when integrated into music compared to a notification sound played on its own?*

According to answers from participants in the questionnaire, the disturbance of receiving a notification while doing a task depends on the type of task. If a task is mentally more demanding, participants perceive it as very disturbing. If a task is not demanding, participants perceive it as not as disturbing.

Experiment 2 tested how disturbing a notification is when played in different contexts. Notification sounds integrated into music samples scored lower on disturbance than notification sounds played on its own. Notification sounds integrated into music had a significant effect on perceived disturbance while doing a task compared to a notification played on its own. Thus, notifications integrated into music were perceived as less disturbing than a notification played on its own.

RQ3*: How disturbing are notification sounds while performing a task when integrated into music compared to a notification sound combined with background sound?*

Overall, notification sounds integrated into music samples scored lower on disturbance than notification sounds combined with background sound. Notification sounds integrated into music had a significant effect on disturbance compared to a notification played with background sound. Thus, notifications integrated into music were perceived as less disturbing than a notification played on its own.

7.1 Limitations of the experiment

The situation in the experiment is not completely close to real life. First, the disturbance of the sound is measured, while in a real-life situation, the notification represents a message.

Secondly, only a part of a song is played. This makes the experiment less representative of real life. In a real-life situation, a whole song is played instead of only a part of the song.

Thirdly, in a normal situation, people would not be asked to listen to a notification sound. The notification sound would be received unexpectedly. This unexpected nature of notification could cause an extra disturbance. The experiment does not cause full disturbance because the notification is not unexpected, and the notification lacks a message.

Learning curve

In both experiments, a learning curve was found. Participants noticed the three different notification sounds and over time they learned how to recognize these notification sounds better. The learning curve can be one of the possible reasons for higher scores in the second part of the experiment. In previous sections of the paper, the expectation was that the training phase would also influence the score of correctly recognizing the notifications. However, this turned out not to be the case.

Limitations of these type of notifications

In the experiment, only three notifications are used. It is possible to create more notifications that can be integrated into the music. However, not all types of notifications can be integrated into the music. Especially when a notification sound is quite long or complex, it is more difficult to fit within another piece of music.

Furthermore, since not all notifications can be integrated, it means a lack of choice of notification sounds for the user. This is a huge limitation for the user as customization adds a much more personal touch and can be satisfying for people. To integrate notifications into music, the customization part of notification is likely to suffer. However, because notification sounds need to be simple to be integrated into the music, it can also be an advantage, as users may create their own notification sound.

Additionally, each piece of music with an integrated notification is created manually. This is a time-consuming process, which is not favorable when used on a large scale.

Convenience sampling

Convenience sampling was used (N = 62). This means that it could have some effects on the generalizability of the data, and it might not be the best sample to represent the population. Some participants might have shared factors due to personal network (same age groups). However, the data gives new insights and adds value.

Music as a choice

Can we say that music is a good choice to use in combination with notifications? Especially when music has been used habitually, people can become motivated to limit attention to music (David et al., 2015). However, some participants found music distracting, especially when music is played while during a task that demands a lot of attention. In our research, most participants somewhat agreed that notifications integrated into music are less distracting. Overall, to integrate notifications into music to make them less distracting would be preferable during tasks that require little mental effort. In tasks requiring higher mental effort, the music itself could be a distracting factor which is not favorable. Even though notification integrated into music is found less distracting, other solutions should be found when performing tasks requiring high mental effort.

7.2 Future research

As already mentioned above, only the disturbance of the actual sound is measured. In further research, the disturbance of both the sound and the message can be measured. An example of such a study is to set up a background story and to let participants respond to a person via text or WhatsApp.

Another addition to the experiment that would be closer to real life, is to let the participant receive a notification via a mobile phone. Especially when combined with a backstory, it would be more representative of a real-life situation. The notification should be played unexpectedly. Other additions could be that a person is placed inside a busy environment or a silent room and the experiment should test the difference between the two situations.

Furthermore, whole songs could be played instead of a part of the song. The notifications should appear in different parts of the song. It can be comparable to research by Butz et al. (2005) which plays notifications during ambient soundscape. Instead of an ambient soundscape, complete songs from various genres are used.

In this research, we have made different experiments to test the recognition and disturbance of notification sounds. The part with recognition (Test 1) does not have a task. Possible future research could test this as well.

Additionally, this research used three different types of integration. Future research could add different methods to integrate notifications into music. These different methods can be compared to each other and it could be investigated whether one type of integration would be better. In this research, it was found that none of the different types of integrations had a real effect on recognition or disturbance. This could be different when other types of integrations are introduced.

In this research, notifications integrated into music are compared to notifications played on their own. However, not many sound samples only contained a notification sound. It would be interesting to further investigate more on the disturbance between notifications integrated into music and notifications played by themselves.

Automatic integration of notification sounds into music

In this research, every notification sound has been integrated into music by hand. What would be interesting for future research, is to make this process an automatic process. A program can be written to match the notification sound with the music. If this program can analyze the type of music someone is listening to and adjust the notification sounds based on this music, less intrusive notification sounds can be created. It even can be created for multiple people in a multi-user environment. Each person would get a notification with certain characteristics. For example, one person could receive a notification with three tones going upwards, while another person receives a notification with three tones going downwards. All these different notifications should be integrated with the musical background.

Disturbance, integration, and recognition

A weak negative correlation was found between the disturbance of notifications integrated into music and whether participants find the notifications integrated into the music. A stronger negative correlation was found between recognition of notifications integrated into music and whether participants find the notifications integrated into the music. It could mean that when notifications are more integrated into the music, they are perceived as less disturbing and less recognizable. Further research could investigate these relationships further to find out if this is the case.

8 Conclusion

The goal of this research is to create notifications that are less distracting, but still recognizable. To do this, our research tested whether notifications can be integrated into different genres of music and if these types of notifications are both recognizable and less disturbing.

First of all, a literature review is conducted. This part is explained why audio notifications could be beneficial over visual notifications, as audio notifications can be perceived as more peripherally. It is also explained why notifications integrated into music could be beneficial, as music does not have a large effect on the performance of a task, especially when music is used habitually during multitasking. Previous studies have shown it is possible to create notifications that are integrated into an ambient soundscape. However, no studies have been done yet on the integration of notification sounds in different types of genres. Also, there is no research on comparing the disturbance of audio notifications integrated into music with audio notifications combined with silence or background sound.

After the literature review, two experiments are conducted. Both experiments consist of a questionnaire. The first experiment tests the recognition of notifications integrated into the music. The second experiment tests the disturbance of these notifications compared to notifications combined with background sound or silence. In both experiments, sound notifications are integrated into ten short sound samples of 19 seconds. Participants are asked to listen to these sound samples and are then asked to evaluate if the sound sample contains a notification sound.

The first part of the questionnaire contained a pre-questionnaire. One of the findings of the pre-questionnaire is that music is found to be somewhat disturbing when performing a mentally complex task. Thus, integrating notification sounds into music would be preferable only when combing with mentally easy tasks. More findings can be found in Chapter 4.

8.1 First experiment

In the first experiment for the first ten questions, participants have no clue how the notification sounds sound. Then, a training phase takes place in which the notifications are learned. After this, the same ten sound samples are played again. This is to test if participants can recognize the notification sound in the music sample without learning them.

Recognition of notification sounds integrated into the music

RQ1: *How recognizable are notification sounds when they are integrated into music?*

From the data of the first experiment, it can be concluded that notifications integrated into music are recognizable. In experiment 1, 76% of the notification sounds were correctly recognized before the training phase and 86% after the training phase. In experiment 2, 82% of the notification sounds were correctly recognized.

The results from the questionnaire had shown that participants found the notifications which were integrated into music somewhat recognizable. They also find notifications integrated into music less recognizable compared to notifications played on their own.

Hypothesis: Notification sounds integrated into music are less recognizable if the listener does not know what the notification sound is

One interesting find was that notifications were not more recognizable after the training phase. The training phase did not have a significant effect on the recognition of the notification sounds. Participants scored already well on recognizing the notification sound before the notification sounds were learned.

Additionally, a negative correlation was found between the recognition of a notification sound and whether participants found the notification sound integrated into the music.

8.2 Second experiment

In the second experiment, the disturbance of notifications integrated into music is compared to the disturbance of notifications played by themselves or combined with background sound. Seventeen sound samples with integrated notification sounds are played and participants are asked to evaluate whether these sound samples contain a notification sound. While playing the sound sample, participants are asked to perform a calculation task.

Disturbance of notifications integrated into the music

The data from the second experiment showed that participants find the notifications integrated into music less disturbing compared to notification sounds played on its own or combined with background sound while performing a task. The perceived disturbance was significantly affected by the context of the notification sound.

RQ2*: How disturbing are notification sounds while performing a task when integrated into music compared to a notification sound played on its own?*

Notification sounds integrated into music were significantly less disturbing compared to notification sounds played on their own.

RQ3*: How disturbing are notification sounds while performing a task when integrated into music compared to a notification sound combined with background sound?*

Notification sounds integrated into music were significantly less disturbing compared to notifications combined with background sound.
Additionally, no significant difference was found between a notification sound played on its own and a notification sound that is played with background sound.

Furthermore, a negative correlation has been found between the disturbance of notifications integrated into music and whether participants found the notification sound integrated into the music.

In conclusion, it is possible to create less disturbing notifications, but at the same recognizable. The main contribution of this study is to show that notifications can be integrated into different genres of music and these notifications are perceived as less disturbing compared to notifications played by themselves or combined with background sound. Future research could integrate notification sounds into music automatically, create a situation that is closer to real-life or use whole songs instead of the first part of a song.

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Appendix A: Questions questionnaire

"The goal of the study is to investigate how notification sounds can be made less distracting. We will be testing if notification sounds integrated into music are perceived as less distracting. Your task is to listen to sound samples. Please connect your laptop or computer with either headphones or earbuds. In order to participate, the environment should not distract you and no background sounds should be there.
The following will provide you with information about the experiment that will help you in deciding whether or not you wish to participate.
All information you provide will remain confidential and made anonymous, therefore, your results will not be associated with your name. If for any reason during this study you do not feel comfortable continuing, you may stop at any time and your information will be discarded. Your participation in this study will require approximately 20 minutes. When this study is complete you will be provided with the results of the experiment if you request them. If you have any further questions concerning this study, please feel free to contact me through email: s2076934@umail.leidenuniv.nl. Your participation is voluntary.
At a certain moment in this experiment, you need to do calculations. If you wish, you may write on a piece of paper.

If you agree to participate, please be aware that you are free to withdraw at any point throughout the duration of the experiment without consequences. Thank you for participating, please click the button below to continue."

Pre-test
Pre-questionnaire:
Q1: When receiving a text message, regardless of the content of the notification, what type of notification do you prefer?
1. Sound notifications
2. Visual pop-ups
3. Vibrating notifications

Q2: Why do you prefer this type of notification?

Sound notifications and distraction

Q3: When someone else receives an unexpected message and a sound notification is played, I think this is distracting.
- Completely disagree < 1...5 > Completely agree

Q4: When I receive an unexpected message and a sound notification is played, I think this is distracting.
- Completely disagree < 1...5 > Completely agree

Q5: Sound notifications distract me when I am performing a task that requires little mental effort, such as cleaning
- Completely disagree < 1...5 > Completely agree

Q6: Sound notifications distract me when I am performing a task that requires a lot of mental effort, such as studying
- Completely disagree < 1...5 > Completely agree

Q7: For how many hours a day do you typically listen to music?
1. 0-1
2. 2-4
3. 5-6
4. 7+

Genres of music

Q8: I think some genres of music can be more distracting than other genres of music
- Completely disagree < 1...5 > Completely agree

Q9: My taste in music is pretty diverse
- Completely disagree < 1...5 > Completely agree

Music listening habits

Q10: I listen to music when performing tasks that require little mental effort, such as cleaning
- Completely disagree < 1...5 > Completely agree

Q11: I listen to music when performing tasks that require a lot of mental effort, such as studying
- Completely disagree < 1...5 > Completely agree

Music during task

Q12: When I am performing a task that requires little mental effort, such as cleaning, I think music is distracting.
- Completely disagree < 1...5 > Completely agree

Q13: When I am performing a task that requires a lot of mental effort, such as studying, I think music is distracting.
- Completely disagree < 1...5 > Completely agree

Test 1

After filling in this questionnaire, participants are asked to judge sound samples. Some sound samples contain notification sounds, others do not. The sound notifications are integrated into music.

Test 1.1

“In the following task, you have to listen to certain audio files. You have to guess whether the audio file contains a notification sound or not. The notification sound can consist of any synthesized sound. The first question will be a test question, to give an example of a notification sound. After this question, you need to judge for yourself whether the audio file contains a notification sound. Please note that each sound sample can only be played once. Also, make sure you remember when this notification sound is being played, as this is asked afterwards. It can be a rough estimate, it doesn't have to be precise.”

Q1: According to you, do you think this audio file contains one or more notification sounds?
- Yes, one notification sound
- Yes, multiple notification sounds
- No

Q2: At what time was the notification sound played?
- 1 - 19 seconds

Q3: I think the notification sound(s) are recognizable.

- Completely disagree < 1...5 > Completely agree

Q4: The notification sound(s) are part of the rest of the music -> The notification sound(s) sounds as if it is part of the music

- Completely disagree < 1...5 > Completely agree

Training phase
After the pre-test, a training phase is established. In this phase, notification sounds will be learned. Participants hear every notification sound without any music. The participant is told these sounds are notification sounds. Three different notification sounds exist.

"This is the training phase in which notification sounds are learned. Please play each notification sound repeatedly, to make sure you will remember each one of them well. Try to remember the order of the notification sounds as well. "

Q1: I think this notification sound is easily recognizable <1...5>
Q2: I think this notification sound would disturb me <1...5>

Q3: How would you rank these notifications according to your preference? Please drag the most preferred one to the top and the least preferred one to the bottom.
Q4: Why do you favor this notification sound?

Test 1.2
This phase uses the same sound samples before the training phase. However, the difference is that participants have learned the notification sounds. Participants are asked to judge whether a notification sound is played while playing music. Ten different sound samples are played. No other additional task is asked.

"Ten different sound samples are played. Please judge whether you think a notification sound is played."

Q: According to you, do you think this audio file contains one or more notification sounds?

- Yes, one notification sound
- Yes, multiple notification sounds
- No

Q: I think the notification sound(s) are recognizable

- Completely disagree <1...5> Completely agree

Q: The notification sound(s) are part of the rest of the music

- Completely disagree <1...5> Completely agree

Test 2

In the other experiment (test 2), participants are asked to judge the disturbance of the notification sounds. Seventeen different sound samples are used. Participants are asked to multitask. While performing a task, they are asked to judge whether the playing sound sample contains a notification sound.

Main task:

"The following task consists of several questions. During these questions, either music or background sound is played. During some questions, a notification sound is played. During other questions, no notification sound is played. You are asked to judge whether the sound sample contains a notification sound or not.

You also need to do a small calculation task, which needs to be finished within 20 seconds. The first question will be a test question, to make sure you understand what to do. You are allowed to write on a piece of paper to do calculations.

If you hear silence, please continue to listen, and do not stop the audio fragment.

The following notification sounds are being used. Please remember which notification sound is the first, which one is the second and which one is the third. It will be asked which notification sound is played."

Extra information: the questions below are asked as follows: "What is (1+5)/2*3?" and possible answers are 1, 2, 4 or 9. Participants are asked to select the correct answer (which is 9 in this case).

Test question: (1 + 5) / 2 * 3 = { 1, 2, 4, 9 }

Q1: 5 * 7 - 8 / 2 = { 31, - 2.5, 15, 28 }
Q2: (28 + 2) / 15 + 8 * 2 = { 18, 2.6, 0.96, 14 }
Q3: 6 + 9 * 3 = { 33, 81, 45, 48 }
Q4: 9 / 3 + 6 * 7 = { 45, 7, 0.2, 27 }
Q5: 6 * 8 - 2 = { 46, 36, 28, 48 }

Q6: 5 * 5 + 3 * 2 = { 31, 80, 56, 55 }
Q7: (56-32)/6 = { 4, 50.6, 28, 31 }
Q8: 5 + 9 / 3 + 6 = { 14, 10.6, 6, 1.55}
Q9: 4 * 8 + 9 * 3 = { 59, 204, 140, 123 }
Q10: 5 * 6 - 3 * 6 = { 12, 90, -60, 162 }

Q11: 6 * 8 - 4 * 6 = { 24, 144, -96, 264 }
Q12: 6 * 5 - 7 * 2 = { 16, -24, -54, 46 }
Q13: 4 * 6 + 9 * 3 = { 51, 180, 132, 99 }
Q14: (52-24)/4 = { 7, 46, 6, 16 }
Q15: 4 + 9 * 2 + 8 = { 22, 86, 18, 44 }

Q16: 21 / 7 + (24-16) * 4 = { 35, 0.5, 34, -37 }
Q17: 7 * 9 - 8 * 3 = { 39, 21, 165, -105 }

Q2: According to you, do you think this audio file contains a notification sound?
- Yes
- No

Q4: The notification sound sounds as if it is part of the music or background sound
- Completely disagree < 1…5 > Completely agree

Q6: I think this notification sound would disturb me
- Completely disagree < 1…5 > Completely agree

Posttest

Additional questions are asked. For group 1, only the first three questions are asked, as this group does not do any mental arithmetic.

Notifications integrated into music

Q1: Notifications integrated into music can be less distracting

- Completely disagree < 1..5 > completely agree

Q2: Notifications integrated into music are recognizable

- Completely disagree < 1..5 > completely agree

Q3: Notifications that are integrated into music are equally recognizable as when played on their own

- Completely disagree < 1...5 > completely agree

Mental arithmetic

Q4: I am able to do mental arithmetic quite easily

- Completely disagree < 1...5 > completely agree

Q5: The mental arithmetic tasks in this research were easy to do

- Completely disagree < 1...5 > completely agree

"Thank you so much for your participation. This is the end of the experiment. If you have any questions or wish to view results of the research feel free to email me at s2076934@umail.leidenuniv.nl."

Appendix B: Notifications and sound samples

Song	Notification sound	Song	Notification sound
1. Kielokaz	None	6. Last bar guests	2
2. Tintamare	2	7. Tintamare 2	1
3. Paper lanterns	1	8. Checkie Brown	3
4. Upbeat party	1	9. Monplaisir	1
5. Cute keys	None	10. Coming to dinner	3

Table 1. Experiment 1: music samples and notification sound

Song	Notification sound	Song	Notification sound	Song	Notification sound
1. Tintamare 2	1	6. Cute keys	None	11. Large crowd	3
2. Last bar guests	2	7. Stream of water	2	12. Thunder	None
3. Silence	3	8. Silence	1	13. Coming to dinner	3
4. River	2	9. Howling wind	3	14. Silence	2
5. In the woods	1	10. Monplaisir	1	15. Upbeat party	1
				16. Tintamare	2
				17. Crickets	3

Table 2. Experiment 2: sound samples and notification sound

Hyperlinks to music samples
Tintamare - Ma Tropicalité
Tintamare - Propane
Checkie Brown - Mary Roose
Kielokaz - Trip to Ganymed
springtide - Paper Lanterns in the Dusk
Scott Holmes - Upbeat Party
tkky - Cute keys
Monplaisir - Stage 1 Level 24
Collection of Lone Souljahs - Guess Whos Coming To Dinner Medley
Lobo Loco - Last Bar Guests

Hyperlinks for background sound samples
River
In the woods
Stream of water
Howling wind
Large crowd
Thunder
Crickets
Chickens

Appendix C: Visual graphs pre-test

Q1: When receiving a text message, regardless of the content of the notification, what type of notification do you prefer?

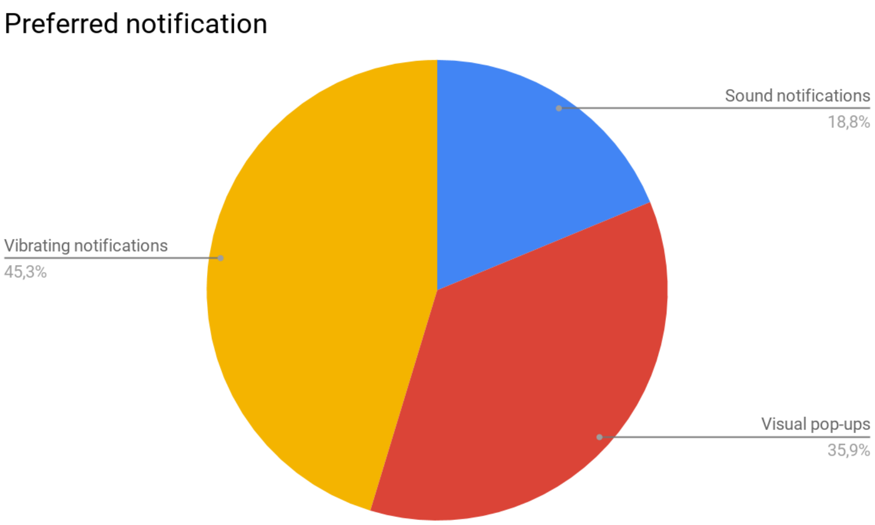

Figure 1. Results from both questionnaires

Q3: When someone else receives an unexpected message and a sound notification is played, I think this is distracting.
Q4: When I receive an unexpected message and a sound notification is played, I think this is distracting.
Q5: Sound notifications distract me when I am performing a task that requires little mental effort, such as cleaning
Q6: Sound notifications distract me when I am performing a task that requires a lot of mental effort, such as studying

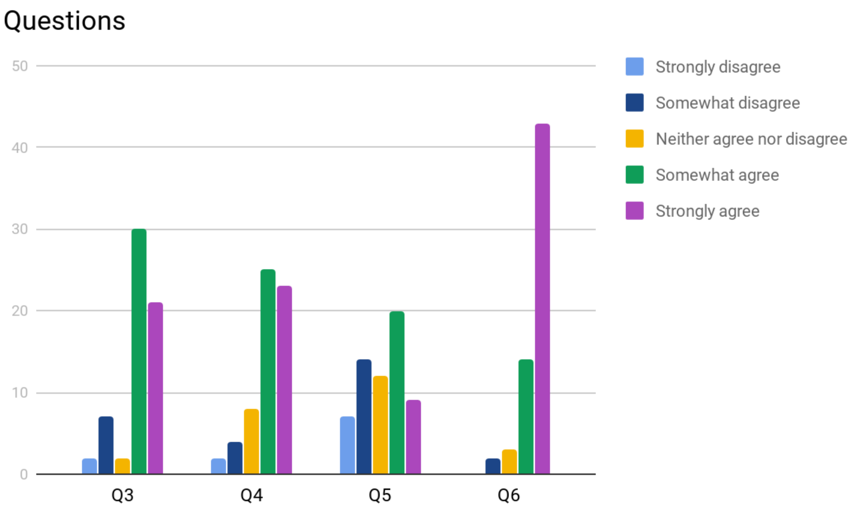

Figure 2. Results from both questionnaires for Q3-6

Q7: For how many hours a day do you typically listen to music?

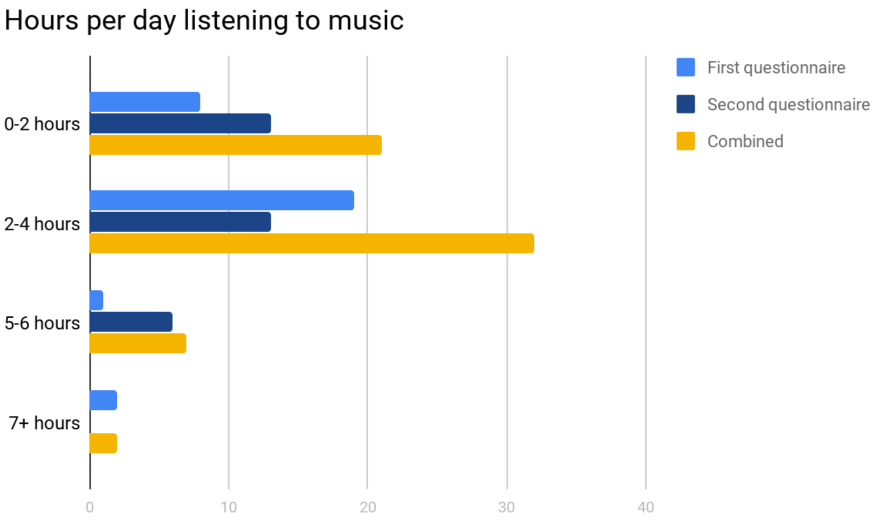

Figure 3. Results for both questionnaires for Q7

Genres of music

Q8: I think some genres of music can be more distracting than other genres of music
Q9: My taste in music is pretty diverse
Q10: I listen to music when performing tasks that require little mental effort, such as cleaning
Q11: I listen to music when performing tasks that require a lot of mental effort, such as studying
Q12: When I am performing a task that requires little mental effort, such as cleaning, I think music is distracting.
Q13: When I am performing a task that requires a lot of mental effort, such as studying, I think music is distracting.

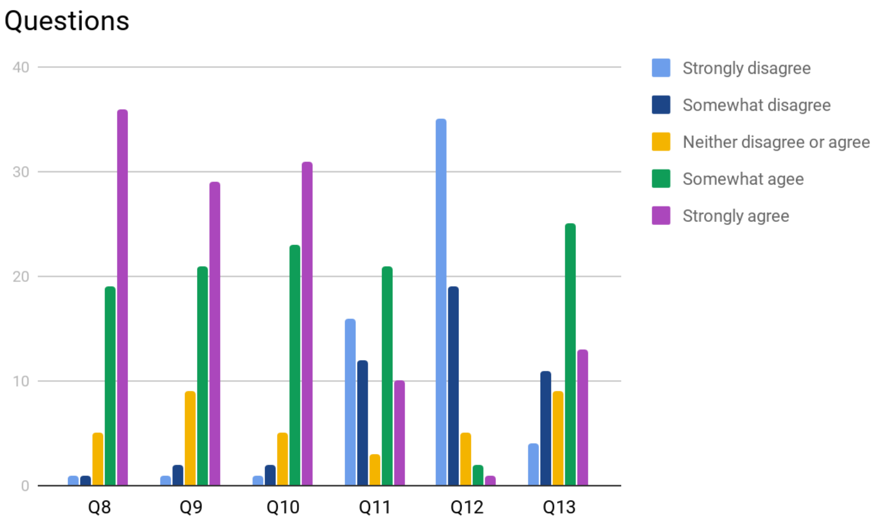

Figure 4. Results for both questionnaires Q8-Q13

Appendix D: Actual results pre-test

Q3: When someone else receives an unexpected message and a sound notification is played, I think this is distracting.
Q4: When I receive an unexpected message and a sound notification is played, I think this is distracting.
Q5: Sound notifications distract me when I am performing a task that requires little mental effort, such as cleaning
Q6: Sound notifications distract me when I am performing a task that requires a lot of mental effort, such as studying

	First questionnaire	Second questionnaire	Combined
Sound notifications	6	6	12
Visual pop-ups	12	10	22
Vibrating notifications	12	16	28

Figure 1. Preferred notification per questionnaire (Q1)

Question	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Q3	2	3	1	11	13
Q4	2	3	3	12	10
Q5	6	3	5	11	5
Q6	0	2	2	4	22

Figure 2. Results from first questionnaire (Q3 - Q6)

Question	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Q3	0	4	1	19	8
Q4	0	1	5	13	13
Q5	1	11	7	9	4
Q6	0	0	1	10	21

Figure 3. Results from second questionnaire (Q3 - Q6)

Ques-tion	Strongly disa-gree	Somewhat disa-gree	Neither agree nor disagree	Somewhat agree	Strongly agree
Q3	2	7	2	30	21
Q4	2	4	8	25	23
Q5	7	14	12	20	9
Q6	0	2	3	14	43

Figure 4. Results from both combined (Q3 - Q6)

Q7: For how many hours a day do you typically listen to music?

	0-1 hours	2-4 hours	5-6 hours	7+ hours
First questionnaire	8	19	1	2
Second questionnaire	13	13	6	0
Combined	21	32	7	2

Figure 5. Results from first questionnaire, second questionnaire and combined (Q7)

Q8: I think some genres of music can be more distracting than other genres of music
Q9: My taste in music is pretty diverse
Q10: I listen to music when performing tasks that require little mental effort, such as cleaning
Q11: I listen to music when performing tasks that require a lot of mental effort, such as studying
Q12: When I am performing a task that requires little mental effort, such as cleaning, I think music is distracting.
Q13: When I am performing a task that requires a lot of mental effort, such as studying, I think music is distracting.

Ques-tion	Strongly disa-gree	Somewhat disa-gree	Neither agree nor disagree	Somewhat agree	Strongly agree
Q8	0	0	2	9	19
Q9	0	2	2	10	16
Q10	0	0	2	13	15
Q11	7	4	1	14	4
Q12	19	8	1	2	0
Q13	1	8	3	11	7

Figure 6. Results from the first questionnaire questions (Q8 - 13)

Question	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Q8	1	1	3	10	17
Q9	1	0	7	11	13
Q10	1	2	3	10	16
Q11	9	8	2	7	6
Q12	16	11	4	0	1
Q13	3	3	6	14	6

Figure 7. Results from second questionnaire questions (Q8 - 13)

Question	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Q8	1	1	5	19	36
Q9	1	2	9	21	29
Q10	1	2	5	23	31
Q11	16	12	3	21	10
Q12	35	19	5	2	1
Q13	4	11	9	25	13

Figure 8. Results from both questionnaire questions (Q8 - 13)

Appendix E: Mode and IQR for pre-test

	mode (questionnaire 1)	median (questionnaire 1)	mode (questionnaire 2)	median (questionnaire 2)	mode (both questionnaires)	median (both questionnaires)
Q1	Vibrating notifications		Vibrating notifications		Vibrating notifications	
Q2						
Q3	5	4	4	4	4	4
Q4	4	4	5	4	4	4
Q5	4	4	2	3	4	3
Q6	5	5	5	5	5	5
Q7	2-4 hours	2-4 hours	0-1 hours	2-4 hours	2-4 hours	2-4 hours
Q8	5	5	5	5	5	5
Q9	5	5	5	4	5	4
Q10	5	4.5	5	4.5	4	4.5
Q11	4	4	1	2	4	3.5
Q12	1	1	1	1.5	1	1
Q13	4	4	4	4	4	4

Figure 1. Mode and median for each questionnaire and combined (Q1-13)

	IQR - test 1	IQR - test 2	IQR - combined
Q3	1	0.25	1
Q4	1.75	1	1
Q5	2	2	2
Q6	0.75	1	1
Q7	0.75	1	1
Q8	1	1	1
Q9	1	1.25	1
Q10	1	1	1
Q11	2	3	2.75
Q12	1	1	1
Q13	2	1	2

Figure 2. Interquartile range (Q3 - Q13)

Appendix F: Summary test 1

According to you, do you think this audio file contains a notification sound?

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Yes	6	27	13	27	4	16	22	29	27	23
Yes, multiple	4	0	3	2	0	0	0	0	1	4
No	20	3	14	1	26	14	8	1	2	3

Table 1. Results from the first part (before training)

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Yes	5	28	17	30	2	25	26	29	29	24
Yes, multiple	3	1	3	0	0	1	0	0	0	1
No	22	1	10	0	28	4	4	1	1	4

Table 2. Results from the second part (after training)

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
before training	66	83	40	86	86	50	63	90	86	66
after training	73	93	56	86	90	76	80	90	90	76

Table 3. Percentage of participants correctly recognizing the notification sound

Which songs are more integrated?

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
Mdn	3.5	3	4	3	5	4	4	2	2	4	3
IQR	2.75	2	2.25	1	1.5	1	1	1	1	2	2
Mdn	5	2	4	2	4	4	2	2	2	3	2
IQR	1	2	1.5	1	1	1	2.75	1	1	2	2

Table 4. The median and interquartile range for question 1-10, before and after the training phase

Which songs are more recognizable?

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
Mdn	4	4	3.5	4	3.5	4	4	4	5	4	4
IQR	1	1	2	0	1.5	2	1.75	1	1	2	2
Mdn	3	4	4	4	2.5	4	4	4	4.5	4	4
IQR	3.25	1	2	0	0.5	2.75	1.5	1	1	0	1

Table 5. Median and interquartile range for question 1-10, before and after training phase

The three different types of integration:

1. On the same beat
2. Not on the same beat, but in the tempo of the song
3. Fits in schema

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
int		2	1, 3	2, 3		2	1, 3	2	2, 3	2, 3

Table 6. Type of integration for question 1-10

Appendix G: Actual results test 1

Test question:

According to you, do you think this audio file contains one or more notification sounds?

Yes, one notification sound	26
Yes, multiple notification sounds	3
No	1

Table 1. Results from test question

At what time was the notification sound played? (in seconds)

Seconds	1	3	4	5	6	7	8
Frequency	1	6	6	5	2	2	4

Table 2. Guessed time of notification sound

Q3: I think the notification sound(s) are recognizable
Q4: The notification sound(s) sounds as if it is part of the music

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
Q3	0	0	0	10	19
Q4	12	6	6	5	0

Table 3. Recognition and integration

Results from Test 1.1 and Test 1.2

Q14: I think the notification sound(s) are recognizable
Q15: The notification sound(s) sounds as if it is part of the music

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q14	0	1	0	5	4	4	4	1
Q14 (after training)	3	1	0	2	2	1	3	3.25
Q15	3	1	1	3	2	4	3.5	2.75
Q15 (after training)	1	0	0	2	5	5	5	1

Table 4. First sound sample before/after training

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q14	0	2	2	13	10	4	4	1
Q14 (after training)	0	1	1	16	11	4	4	1
Q15	5	6	4	10	2	4	3	2
Q15 (after training)	11	6	5	6	1	1	2	2

Table 5. Second sound sample before training

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q14	1	6	1	5	3	2	3.5	2
Q14 (after training)	1	5	3	8	3	4	4	2
Q15	0	4	2	5	5	4.5	4	2.25
Q15 (after training)	4	1	4	6	5	4	4	1.5

Table 6. Third sound sample before training

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q14	0	5	2	19	3	4	4	0
Q14 (after training)	1	0	1	21	7	4	4	0
Q15	3	4	8	11	3	4	3	1
Q15 (after training)	4	15	4	4	3	2	2	1

Table 7. Fourth sound sample before training

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q14	1	0	1	1	0	-	3.5	1.5
Q14 (after training)	1	0	0	1	0	-	2.5	0.5
Q15	0	0	1	0	3	5	5	1.5
Q15 (after training)	0	0	1	0	1	-	4	1

Table 8. Fifth sound sample before training

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q14	0	5	0	8	3	4	4	2
Q14 (after training)	1	8	2	8	7	-	4	2.75
Q15	0	0	2	9	5	4	4	1
Q15 (after training)	1	2	3	12	8	4	4	1

Table 9. Sixth sound sample before training

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q14	1	5	4	9	3	4	4	1.75
Q14 (after training)	1	2	4	12	7	4	4	1.5
Q15	2	5	1	7	7	4.5	4	3
Q15 (after training)	7	8	2	5	4	2	2	2.75

Table 10. Seventh sound sample before training

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR

Q14	0	2	4	11	12	5	4	1
Q14 (after training)	0	1	1	17	10	4	4	1
Q15	7	11	7	3	1	2	2	1
Q15 (after training)	11	10	3	4	1	1	2	2

Table 11. Eighth sound sample before training

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q14	0	1	1	11	15	5	5	1
Q14 (after training)	0	1	1	13	15	5	4.5	1
Q15	9	13	2	3	1	2	2	1
Q15 (after training)	14	9	3	3	1	1	2	1

Table 12. Ninth sound sample before training

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q14	1	9	3	11	3	4	4	2
Q14 (after training)	2	1	1	17	4	4	4	0
Q15	1	7	5	8	6	4	4	2
Q15 (after training)	3	9	4	4	5	2	3	2

Table 13. Tenth sound sample before training

Results timing of notification sound

	Correct	**Mean**		**Median**	
		Before	After	Before	After
Q1					
Q2	10	9.8	10.3	10	10
Q3	4	3.61	4.4	4	4
Q4	6	6.44	6	6	6
Q5					
Q6	2	2.5	4	2.5	3
Q7	5	5.4	5.3	5	5
Q8	6	6.9	6.6	7	7
Q9	8	8.8	8.6	9	9
Q10	5	5	5.6	5	5
Average difference		**0.45**	**0.6**	**0.31**	**0.38**

Table 14. Mean difference and median difference

Appendix H: Bubbleplots

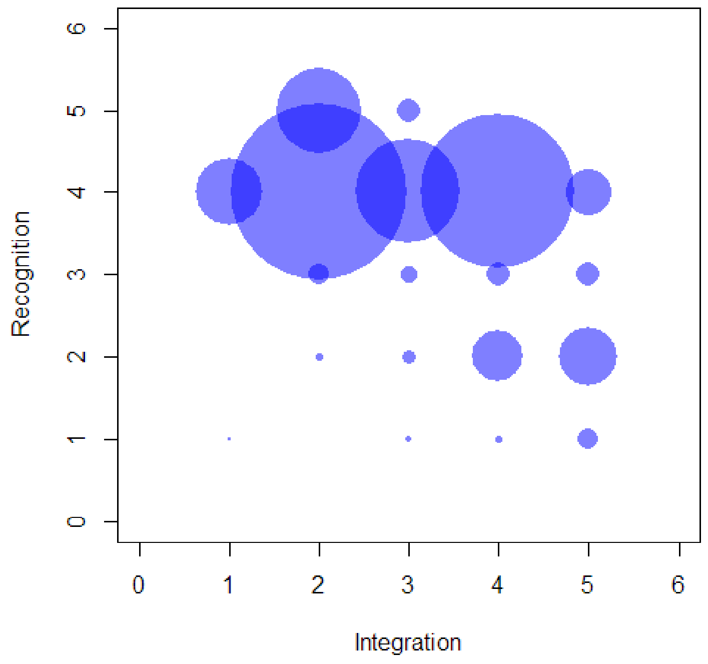

Figure 1. Correlation between recognition and integration

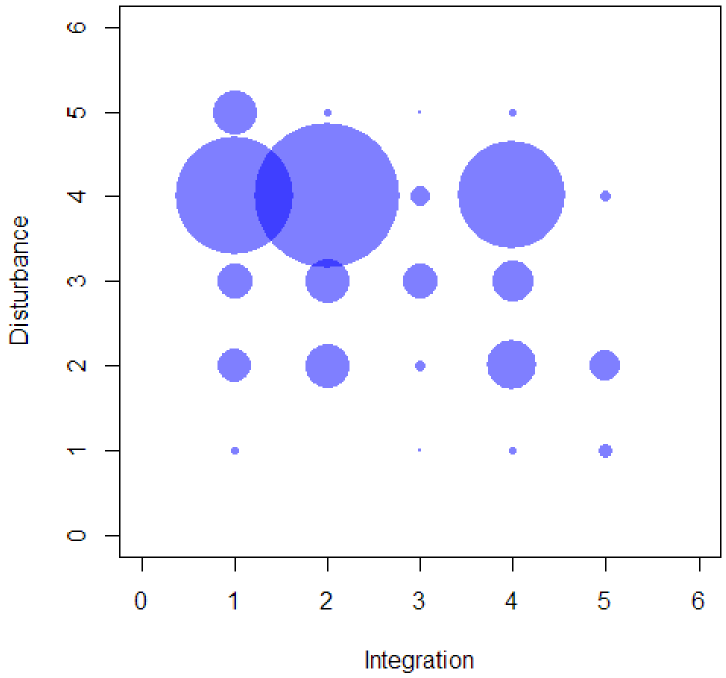

Figure 2. Correlation between disturbance and integration (all conditions)

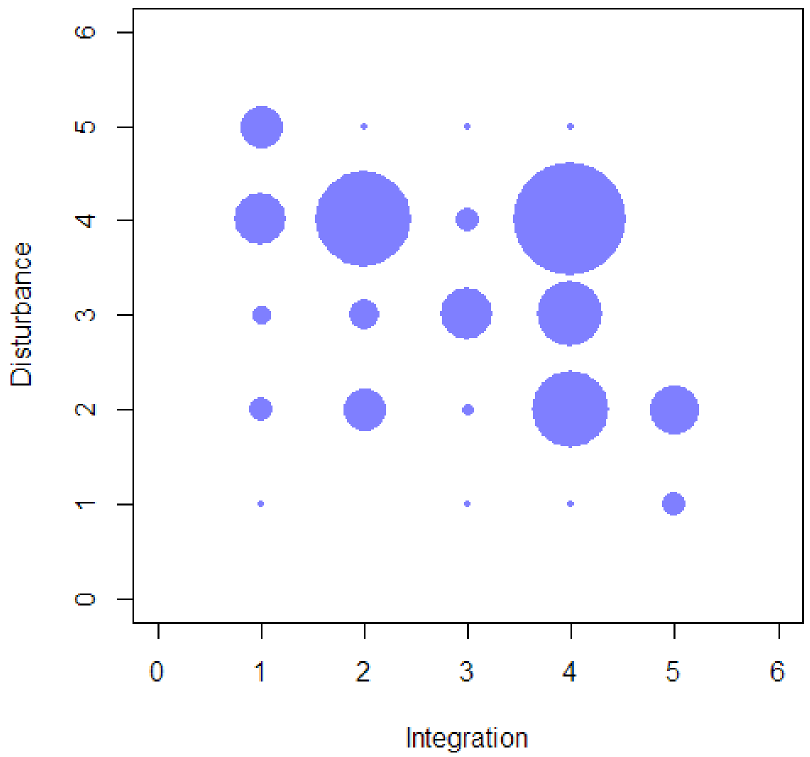

Figure 3. Correlation between disturbance and integration (music condition)

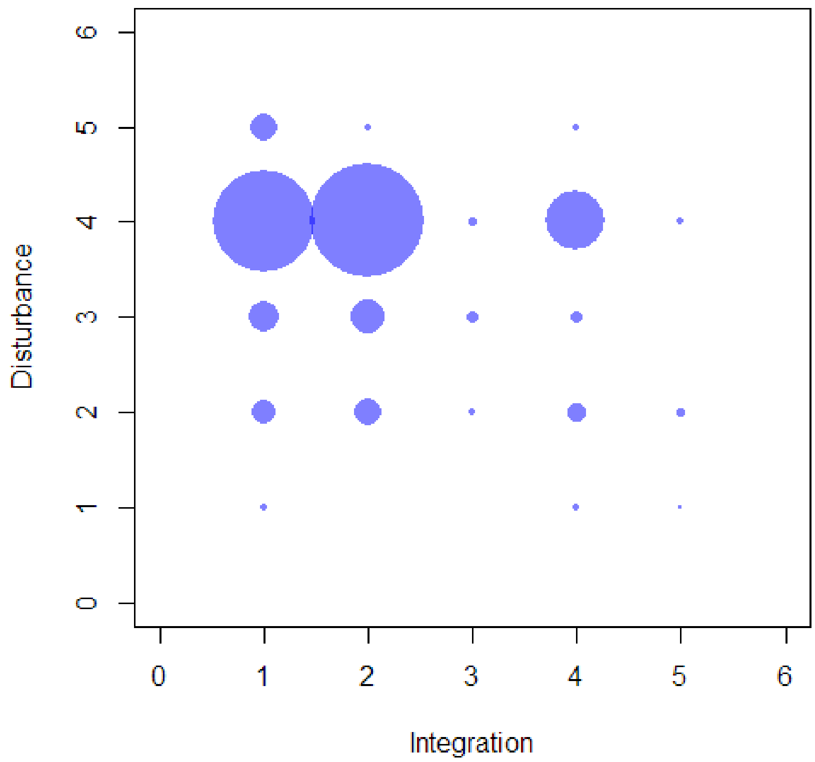

Figure 4. Correlation between disturbance and integration (background condition)

Kruskal-Wallis Test

Kruskal-Wallis Test

Factor	Statistic	df	p
COND	11.731	2	0.003

Post Hoc Tests

Standard

Post Hoc Comparisons - COND

		Mean Difference	SE	t
Background	Music	0.337	0.121	2.789
	Sound	−0.067	0.138	−0.488
Music	Sound	−0.404	0.145	−2.785

Note. P-value adjusted for comparing a family of 3

Dunn

Dunn's Post Hoc Comparisons - COND

Comparison	z	W_i	W_j	p	p_{bonf}	p_{holm}
Background - Music	2.777	204.803	170.796	0.003	0.008	0.005
Background - Sound	−0.817	204.803	216.186	0.207	0.621	0.207
Music - Sound	−3.088	170.796	216.186	0.001	0.003	0.003

Figure 5. JASP Kruskal-Wallis test (music, background and sound)

Appendix I: Training phase test 1 results

Training phase
Q16: I think this notification sound is easily recognizable
Q17: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
Q16 - 1st	0	1	0	20	9
Q17 - 1st	3	7	11	8	1
Q16 - 2nd	2	2	5	9	12
Q17 - 2nd	2	8	6	11	3
Q16 - 3rd	0	1	3	16	10
Q17 - 3rd	4	7	7	11	1

Figure 1: First, second and third notification sound

How would you rank these notifications according to your preference? Please drag the most preferred one to the top and the least preferred one to the bottom

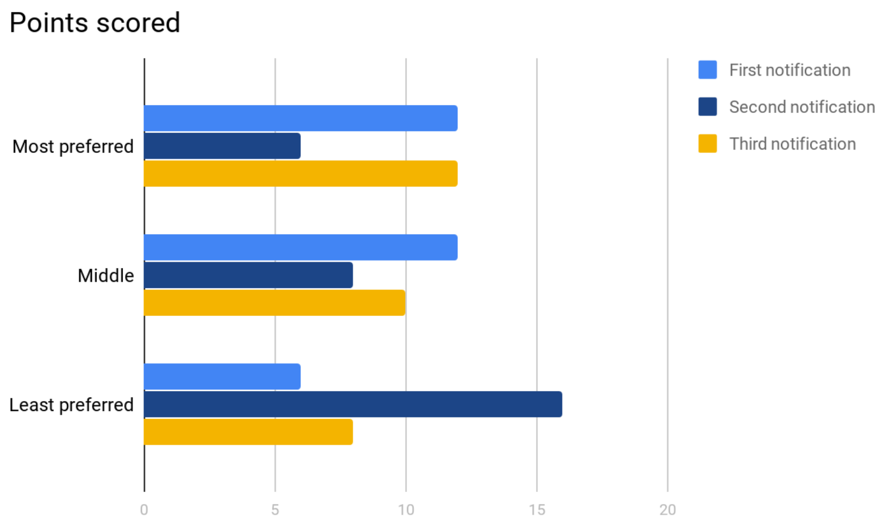

Figure 2. Preferred notifications in order

Appendix J: Summary test 2

Q6 and 12 are marked red, as they contained no notification sound. Q3, 8 and 14 contained only a notification sound, thus the question "The notification sound sounds as if it is part of the music or background sound" is not asked. Therefore, in Table 3 contain empty spaces for these questions.

According to you, do you think this audio file contains a notification sound?

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Y	11	16	29	27	30	1	30	28	28	27	31	1	24	29	23	28	28
N	21	16	3	5	2	31	2	4	4	5	1	31	8	3	9	4	4

Table 1. Number of participants answering yes or no

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
%	34	50	90	84	93	96	93	87	87	84	96	96	75	90	71	87	87

Table 2. Percentages of participants answering question correctly

Which songs are more integrated?

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Mdn	4	4		2	2	4	2		1	2	2	1	4		3	2	2
IQR	1	0.5		3	2	0	3		0.25	2	1	0	2		1.5	2	1

Table 3. Median and interquartile range for each

Which songs are more disturbing?

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Mdn	2	3	4	4	4	4	4	4	4	3	4	4	3	4	3	4	4
IQR	2	2	2	1	1	0	1.75	1.25	0.25	1.5	0	0	2	1	2	1	1

Table 4. Median and interquartile range for each question

Appendix K: Calculation tasks

How many calculation tasks were correct? (in percentages and frequency)

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
%	44	53	90	84	90	90	90	59	90	93	93	96	88	81	88	50	68
Nr	14	17	29	27	29	29	29	19	29	30	30	31	28	26	28	16	22

Table 1. Number of participants who had the calculation task correct, also expressed in percentages

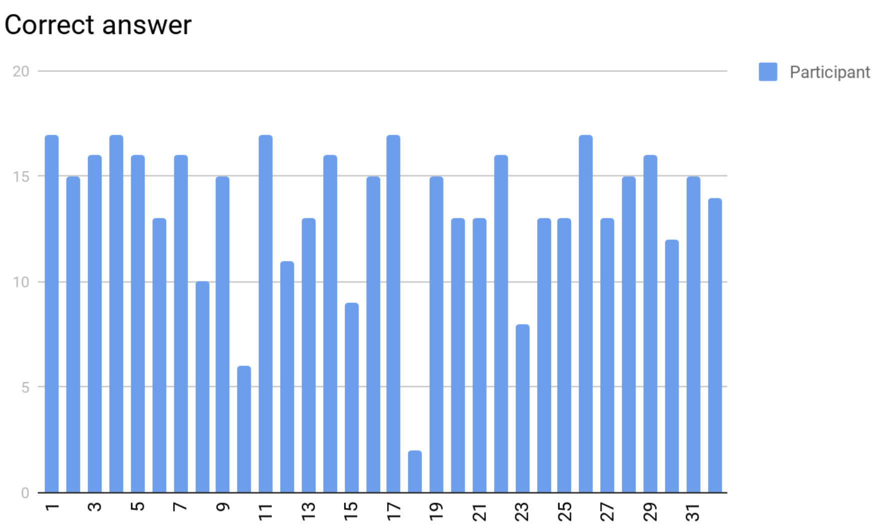

Figure 1. Correct answer per participant

Appendix L: Actual results test 2

Test question
What is (1+5) / 2 * 3?

Answer	1	4	9 (correct answer)
Frequency	15	2	12

According to you, do you think this audio file contains a notification sound?

No	Yes
14	18

Which notification sound was being played?

Not sure	Sound 1	Sound 2 (correct answer)
3	3	12

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
Q1	4	7	0	7	0
Q2	0	4	5	8	1

Question 1:
What is 5 * 7 / 2?

Answer	-2.5	15	28	31 (correct answer)
Frequency	1	6	1	14

According to you, do you think this audio file contains a notification sound?

No	Yes
21	11

Which notification sound was being played?

Not sure	Sound 1 (correct answer)	Sound 2	Sound 3
2	5	2	3

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	2	0	2	5	2	4	4	1
Q2	3	4	1	3	0	2	2	2

Question 2
What is (28 + 2) / 15 + 8 * 2?

Answer	0.96	2.6	18 (correct answer)
Frequency	8	1	17

According to you, do you think this audio file contains a notification sound?

No	Yes
16	16

Which notification sound was being played?

Not sure	Sound 2 (correct answer)	Sound 3
2	12	3

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	1	2	1	8	4	4	4	0.5
Q2	1	6	3	5	1	2	3	2

Question 3
What is 6 + 9 * 3?

Answer	33 (correct answer)	45	48	81
Frequency	29	0	0	1

According to you, do you think this audio file contains a notification sound?

No	Yes
3	29

Which notification sound was being played?

Not sure	Sound 1	Sound 2	Sound 3 (correct answer)
1	3	2	23

Q1: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	3	6	4	13	3	4	4	2

Question 4

What is 9 / 3 + 6 * 7?

Answer	0.2	7	27	45 (correct answer)
Frequency	1	0	1	27

According to you, do you think this audio file contains a notification sound?

No	Yes
5	27

Which notification sound was being played?

Not sure	Sound 1	Sound 2 (correct answer)	Sound 3
5	2	19	1

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	8	6	4	8	1	-	2	3
Q2	0	6	6	14	1	4	4	1

Question 5

What is 6 * 8 - 2?

Answer	28	36	46 (correct answer)	48
Frequency	1	1	29	0

According to you, do you think this audio file contains a notification sound?

No	Yes
2	30

Which notification sound was being played?

Not sure	Sound 1 (correct answer)	Sound 2	Sound 3
5	19	1	5

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	6	12	2	6	4	2	2	2
Q2	1	5	7	15	2	4	4	1

Question 6
What is 5 * 5 + 3 * 2?

Answer	31 (correct answer)	55	56	80
Frequency	29	2	1	0

According to you, do you think this audio file contains a notification sound?

No	Yes
31	1

Which notification sound was being played?

Not sure
1

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	0	0	0	1	0	4	4	0
Q2	0	0	0	1	0	4	4	0

Question 7
What is (56 - 32) / 6?

Answer	28	31	4 (correct answer)	50.6
Frequency	1	1	29	0

According to you, do you think this audio file contains a notification sound?

No	Yes
2	30

Which notification sound was being played?

Not sure	Sound 1	Sound 2 (correct answer)	Sound 3
2	2	24	2

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree or agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	9	12	0	8	1	2	2	3
Q2	2	6	5	14	3	4	4	1.75

Question 8
What is 5 + 9 / 3 + 6?

Answer	1.55	6	10.6	14 (correct answer)
Frequency	11	0	0	19

According to you, do you think this audio file contains a notification sound?

No	Yes
4	28

Which notification sound was being played?

Not sure	Sound 1 (correct answer)	Sound 2	Sound 3
2	20	2	4

Q1: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree or agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	3	6	4	13	3	4	4	1.25

Question 9
What is 4 * 8 + 9 * 3?

Answer	59 (correct answer)	123	140	204
Frequency	29	2	0	0

According to you, do you think this audio file contains a notification sound?

No	Yes
4	28

Which notification sound was being played?

Not sure	Sound 1	Sound 2	Sound 3 (correct answer)
4	1	0	19

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	16	7	0	4	1	1	1	1
Q2	0	4	3	18	3	4	4	0.25

Question 10
What is 5 * 6 - 3 * 6?

Answer	-60	12 (correct answer)	90	162
Frequency	0	30	0	0

According to you, do you think this audio file contains a notification sound?

No	Yes
5	27

Which notification sound was being played?

Not sure	Sound 1 (correct answer)	Sound 2	Sound 3
1	21	1	4

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	5	0	2	8	5	4	2	2
Q2	1	6	7	12	1	4	3	1.5

Question 11
What is 6 * 8 - 4 * 6?

Answer	-96	24 (correct answer)	144	264
Frequency	0	30	0	0

According to you, do you think this audio file contains a notification sound?

No	Yes
1	31

Which notification sound was being played?

Not sure	Sound 1	Sound 2	Sound 3 (correct answer)
4	7	2	18

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	12	13	0	6	0	2	2	1
Q2	0	3	3	23	2	4	4	0

Question 12
What is 6 * 5 - 7 * 2?

Answer	-54	-24	16 (correct answer)	46
Frequency	0	1	31	0

According to you, do you think this audio file contains a notification sound?

No	Yes
31	1

Which notification sound was being played?

Not sure	Sound 1	Sound 2	Sound 3
0	0	0	1

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	1	0	0	0	0	1	1	0
Q2	0	0	0	1	0	4	4	0

Question 13
What is 4 * 6 + 9 * 3?

Answer	51 (correct answer)	99	132	180
Frequency	28	0	1	0

According to you, do you think this audio file contains a notification sound?

No	Yes
8	24

Which notification sound was being played?

Not sure	Sound 1	Sound 2	Sound 3 (correct answer)
6	2	1	15

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	2	6	1	13	2	4	4	2
Q2	0	10	4	8	2	2	3	2

Question 14
What is (52 - 24) / 4?

Answer	6	7 (correct answer)	16	46
Frequency	3	26	1	0

According to you, do you think this audio file contains a notification sound?

No	Yes
3	29

Which notification sound was being played?

Not sure	Sound 1	Sound 2 (correct answer)	Sound 3
1	1	23	4

Q1: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	1	1	6	14	7	4	4	1

Question 15

What is -4 + 9 * 2 + 8?

Answer	18	22 (correct answer)	44	86
Frequency	1	28	1	0

According to you, do you think this audio file contains a notification sound?

No	Yes
9	23

Which notification sound was being played?

Not sure	Sound 1 (correct answer)	Sound 2	Sound 3
5	10	0	8

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	3	3	6	8	3	4	3	1.5
Q2	1	6	7	7	2	3.5	3	2

Question 16
What is 21 / 7 + (24 - 16) * 4?

Answer	-37	0.5	34	35 (correct answer)
Frequency	3	0	4	16

According to you, do you think this audio file contains a notification sound?

No	Yes
4	28

Which notification sound was being played?

Not sure	Sound 1	Sound 2 (correct answer)	Sound 3
3	1	23	1

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	11	6	5	3	3	1	2	2
Q2	1	2	6	15	4	4	4	1

Question 17
What is 7 * 9 - 8 * 3?

Answer	-105	21	39 (correct answer)	165
Frequency	0	1	22	0

According to you, do you think this audio file contains a notification sound?

No	Yes
4	28

Which notification sound was being played?

Not sure	Sound 1	Sound 2	Sound 3 (correct answer)
2	5	1	20

Q1: The notification sound sounds as if it is part of the music or background sound
Q2: I think this notification sound would disturb me

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q1	12	10	3	2	1	1	2	1
Q2	2	4	5	13	4	4	4	1

Appendix M: Posttest results

Q20: Notifications integrated into music can be less distracting
Q21: Notifications integrated into music are recognizable
Q22: Notifications that are integrated into music are equally recognizable as without music

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
Q20	2	5	7	12	3
Q21	1	6	8	13	1
Q22	6	10	4	6	3

Table 1. results from the last questionnaire from questionnaire 1

	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
Q20	1	3	3	17	8
Q21	1	5	4	16	6
Q22	8	13	7	3	1

Table 2. results from the last questionnaire from questionnaire 2

	Strongly disagree	Somewhat disagree	Neither disagree or agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q20	3	8	10	29	11	4	4	1
Q21	2	11	12	29	7	4	4	1
Q22	14	23	11	9	4	2	2	1

Table 3. results from the last questionnaire combined from both questionnaires

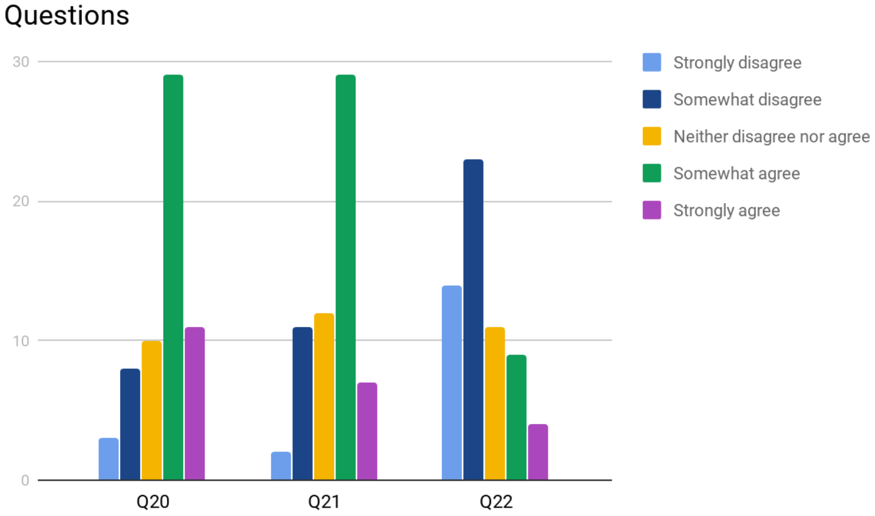

Figure 1. Questions from posttest

Q23: I am able to do mental arithmetic quite easily
Q24: The mental arithmetic tasks in this research were doable

	Strongly disagree	Somewhat disagree	Neither disagree or agree	Somewhat agree	Strongly agree	Mode	Median	IQR
Q23	3	6	7	14	2	4	3.5	2
Q24	0	2	6	16	8	4	4	0.5

Table 4. results from the last questionnaire combined from both questionnaires