Leveraging Sound to Create a Positive User-Interface Experience

Jessica Palmer and Katlin Scott
Department of Computer Science
College of Computing and Software Engineering
Kennesaw State University, Georgia, USA

Abstract- As technology advances, user interface design becomes increasingly more important to recognize when designing things that are going to be seen by many. Therefore, it is imperative to take into consideration various aspects of UI/UX design. While most people focus on only what they can see, that is only part of the experience. Sound plays an integral role in the user experience, and we only have a rough idea of how to use said sound to enhance our experience. Thus, there is a need to research what kind of sound creates a positive experience and enhances what is already there. The approach was to develop and measure the users' accuracy of identification, preference for or against, and general impression of the meaning behind various sounds. We included information about which environment one may hear some of these sounds. We amassed this dataset by means of a survey that encompassed a diverse array of inquiries related to sound, encompassing aspects such as individual sentiments towards sound, sound identification, inclination to revisit a given sound, conjectures regarding sound representations, and overarching preferences. As a result, participants demonstrate a remarkable aptitude for the accurate identification of sounds, the capacity to associate meaning with these sounds, and the ability to commit these associations to memory. Furthermore, certain sounds elicit distinct emotional responses among participants.

Keywords- User Interface (UI), User Experience (UX), UX Sound, Utility, Simplicity, Repetitive Tolerance, Consumer Electronics (CE), Natural Sound, Synthetic Sound, Volume, Timbre, Pitch, Rhythm, Soundscape, Skin Conductance Level (SCL), Heart Rate (HR)

I. INTRODUCTION AND ARRANGEMENT

Everyone has an advertising jingle or a sound that - without hesitation - they could identify which company it came from or what it represents. Think of the Taco Bell "dong" or McDonald's "bata ba bap ba." These sounds often result in an emotional and established opinion about that company, which may either be because of personal experience or a gut reaction in response. However, what makes people have that response? Studies have shown that it may have to do with the sound used. For humans, sound can evoke strong emotions. More specifically, in User Interface (UI) Engineering, it is important to consider the sounds we use or do not use based on the experience we wish the customer to have.

The purpose of our research is to make a case for thoughtful sound integration in user

interfaces and overall user interactions as well as what types of sounds assist in creating a positive experience. The sounds themselves need to deliver the message they wish to convey or the feedback the user needs to aid in using the interface. For example, the chime when your washing machine has finished its cycle would be considered a message, and the beep of the scanner at the grocery store self-checkout as feedback confirming that an item has been scanned.

II. CONCISE LITERATURE REVIEW

Beep! Boop! Buzz! Why Do UX Designers Often Neglect Sound?

An article published by Wired magazine in November of 2018 titled "Beep! Boop! Buzz! Why Do UX Designers Often Neglect Sound?" was the primary inspiration behind this project [1]. The author, Kevin Perlmutter, partnered with Sentient Decision Science to conduct a study that explored the types of sounds, the emotions they inspired, and their willingness to hear those sounds again. Their survey included ten natural sounds and ten synthetic sounds. They also explored the idea of "sonic trash," which was defined as "sounds that are unpleasant, emotionally distressing, and degrading to everyday experiences [1]."

This study demonstrates that sound can result in a positive or negative customer/user experience. The researchers discovered "an 86 percent correlation between how sound makes people feel … and the conscious desire to have or avoid that experience in the future [1]." This is why it is important to consider sounds just as much as visual aesthetics when designing a UI.

The method of their survey has guided our own survey design, but more details will be provided on that in the methods section.

A Survey of UI Sounds Used in Consumer Electronics and User Awareness

Although this is an older study, this one was very directly related to our project, and it offered a great deal of useful information. This study aimed to show the types of sounds used in Customer Electronics (CE), and the sounds that users remember, understand, and enjoy.

The participants' answers showed that 'beeps' were used 81.4% of the time and that they preferred those shorter sounds for "select" feedback sounds like button selection on a microwave and others [2]. They also found that in general, "Users neither like nor dislike these UI sounds totally, but they seem to like 'melody' or 'voice message' better [2]."

It is also interesting to note the method of their study as they required the participants to write out the sound associated with particular CE actions and their meanings. This allowed them to assess how well users memorize sounds and if they can identify what they are intended to mean. The result was that 70.8% of participants' answers were correct [2]. "The fact that the sound and its message are correctly memorized means that the user understands the message correctly when hearing the sound at the real scene [2]."

How everyday sounds can trigger strong emotions: ASMR, misophonia and the feeling of wellbeing

In the study by McGeoch & Rouw, they focused on the brain and its response to sound. They specifically focused on "autonomous sensory meridian response (ASMR) and misophonia—in which certain everyday sounds involuntarily generate strong emotional reactions [3]."

They found that the brain is activated laterally depending on whether the emotional response is positive or negative and that it is important to keep that lateral activation in balance for overall well-being. The chaos of everyday soundscapes can be generally stressful, and this needs to be balanced out. Creating positive or at least neutral user-interface sounds can help.

Sound Advice: A Quick Guide to Designing UX Sounds

Although not formal research papers, several articles talk about and emphasize how the use of sound can always be overlooked when designing for the user. However, it can also be overdone just as easily upon realizing that it is a feature that could be added. According to Leo Foureaux, the primary purpose of sound design of user experience should contribute to "[p]roviding feedback on a user's action or system status" as well as "[d]rawing attention to important information, such as [a] warning or [an] opportunity," but first and foremost, it should be used for utility [4].

For example, if someone were uploading a decently long video on a video-sharing website such as YouTube, we would be expected to do something else while waiting for the video to be uploaded. As such, we would want a pop-up notification indicating when the video finishes uploading, but a sound can aid in that as well to grab your attention if the pop-up is not enough, whether you're distracted or away from your computer.

However, as Dieter Rams has stated, "Good design is as little design as possible" [4]. Sound shouldn't be over-the-top nor be something that ends up repetitiously playing for every notification. Instead, that specific sound should be simple in nature and only played in that specific instance. That way the user is aware that their upload has finished. If there is potentially an error with the upload, that sound should be a different one. Even when you could have a sound for everything, it is not recommended since everyone has "a limit to how often [they] can stand hearing the same sound over and over" [4], which is also called "repetitive tolerance" [4]. A common example of such a term is when you set your favorite song to be your alarm. After a while, it becomes annoying and makes the song no longer your favorite.

Do's and Don'ts of Sound in UX

Abhijit Nayak of Medium wrote an article that not only introduces the topic of sound in UX design and how you should use it but also talks about what instances you would not want to use it in. He mentions that in some instances sound can be "detrimental to [a] user's comfort and focus" [5]. In relation to repetitive tolerance, sounds should not be frequently played. If something is even partially frequently played, there should be an option to mute said sound from an application's interface. Whether it is when you open the interface for the first time, a symbol in the corner, or an option in its settings, it typically is encouraged to ask users if they would like to receive notifications and/or have sound alerts. This is standard because a certain level of privacy or discretion is required in certain locations for certain applications.

For example, imagine you are presenting at a company meeting with a PowerPoint about the current quarter's statistics of your division's sales department on your laptop - or maybe even your phone. Unexpectedly, your health app that is connected to it goes off. In this scenario and others similar to it, personal information - regardless of what it might be - is revealed to non-authorized

parties through notification with sounds as aids. This consideration of "don't" emphasizes the critical nature of having the ability to silence a specific application, device, or otherwise.

Auditory Preferences and Aesthetics: Music, Voices, and Everyday Sounds

This article was published as a chapter in a larger textbook and goes into significant detail about music and individual preferences due to harmonicity and personality traits. However, there were a few related elements within Josh McDermott's work that are relevant for this paper.

Sounds categorized as annoying were typically found to have higher volume, frequency (sharpness), and/or fluctuations in amplitude (roughness) [6].

Although "associations with relaxing circumstances surely play a role" in subjects finding a sound to be pleasant, there are a couple of measurable characteristics that do help to explain generally perceived positive associations to sounds [6]. Sounds with low frequency and slow temporal modulations such as ocean waves, thunderstorms, etc. are generally among the most pleasant/relaxing.

Strong-sound-induced emotional potency and convergent avoidance responses

"Aversive behaviors consist of approach and avoidance behaviors. Approach behavior can be defined as the desire to approach a positive stimulus, while avoidance behavior is the desire to flee, avoid, or resist exposure to a negative stimulus [7]."

Volume or "sound pressure" was shown to cause a significant increase in avoidance responses and their timing as volume increased. All participants in this study clicked the down arrow key to lower the volume when presented with five sounds at 110 dB. This response was selected faster at higher volumes than at the 90 dB and 100 dB sound samples showing a stronger avoidance response.

Associations between positive health-related effects and soundscapes perceptual constructs: a systematic review

This group of researchers reviewed seven studies of soundscapes and their health effects. A soundscape is defined as "an acoustic environment as perceived or experienced and/or understood by a person or people, in context [8]."

The review categorized soundscapes by two dimensions: valence-related (annoying vs pleasant) and activation-related (uneventful vs eventful). This allowed for four types, two of which were considered positive soundscapes and two were considered negative soundscapes:

1. Pleasant and eventful were considered vibrant and positive
2. Pleasant and uneventful were considered calming and positive
3. Annoying and eventful were considered chaotic and negative
4. Annoying and uneventful were considered monotonous and negative

The sounds were considered to have positive health effects if they "enhanced restoration and recovery mechanisms or reduced stress-inducing mechanisms [8]."

A smaller study by Alvarasson et al. of 40 participants was particularly relevant to our paper. Their subjects were presented with four different soundscapes (nature sound, high traffic noise, low traffic noise, and ambient household noise) after completing "a stressful mental arithmetic task [8]". While listening to these sounds, the subjects' heart rate (HR) and skin conductance level (SCL)

were monitored. Using these two metrics, they found that stress recovery time was reduced significantly by nature sounds as compared to any of the other soundscapes.

III. RESEARCH DESIGN METHODOLOGY

This study's main purpose was to determine if there is any significant preference for the types of sounds used in UI design and if users even wished to have sound at all. An experimental survey was conducted to measure the qualities of preference people had for certain sounds and a distaste for others. The visualizations were formed using such gathered data.

A. User Interface Sound Design

Is sound in UI Design necessary? Do the sounds that are used make any difference?

The field of sound design in user interfaces (UI) is not only musical in nature. It can be summarized by its inherent purpose or - in other words - what a sound is supposed to represent and how effective and efficient a sound is in representing a specific purpose. For example, when doing a task in a video game or even a digital, dynamic list, it would be nice to get an auditory response after completing the task. However, sometimes, it is not all that necessary to have a sound behind every action. A noteworthy factor is how important a sound cue is. If it is not important, it doesn't need to have a sound in UI because of how it could be perceived as annoying.

From useful scenarios such as a beep to represent an item being scanned or a card processing a transaction to a document being uploaded and/or submitted to a database or portal, there are a few ways to provide feedback/cues to users in UI design. Certainly, there are visual/graphical indicators and written words, but audio is also an option that is especially useful for users with visual impairments and learning disabilities.

B. Experimental Method

a. *Research Question and Hypothesis*: The secondary emphasis of this study was on measuring the effectiveness of sound in UI. The rest of this section describes the experiment.

Experimental Research Questions:

- Is there potential for increased positive response through the use of increased sound in UI?
- What types of sounds/sound characteristics elicit positive responses in users?

Null Hypothesis:

- H0-1 - There is no significant preference shown for natural sounds or synthetic sounds.
- H0-2 - There is no significant preference shown for the pitch or volume of sounds.

b. *Participants*:
Eighteen participants (n=18) took our experimental survey. Although they stayed anonymous because of the survey form, the majority of participants ranged in age from anywhere between 18 to 35. These participants were sent the survey and asked to complete it within different majors and courses.

c. *Apparatus*: The experiment entailed the utilization of a Google Form, which featured embedded hyperlinks redirecting to an external Wix website. This site hosted the selected sound files in

mp3 format in a virtual player. This arrangement was implemented to prevent the need for the participants to have to download any of the files and to make it easier for those on mobile devices to also take the survey without much of an issue.

The survey could be taken with any device (Windows, Mac, Linux, Android, iOS, etc.) that has access to a web browser and the internet.

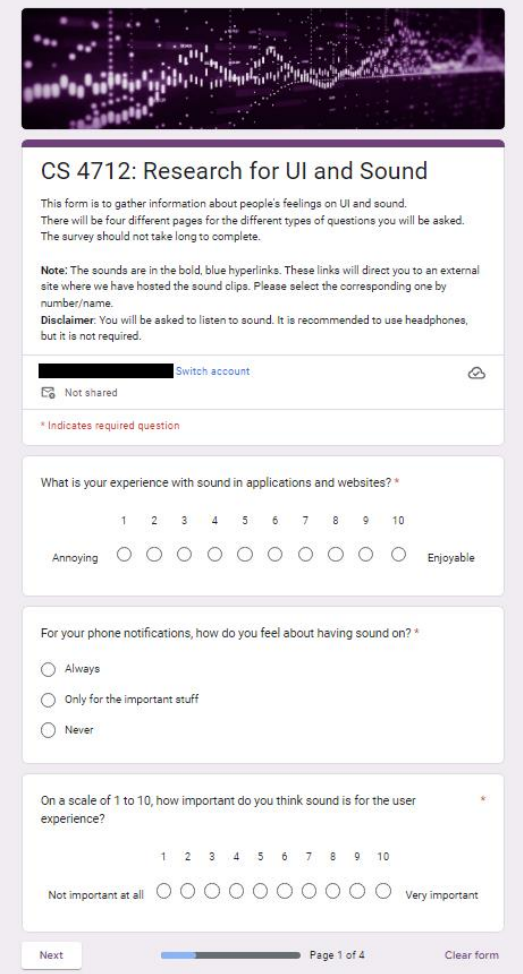

Figure 1. A screenshot of what survey-takers saw when agreeing to take the survey.

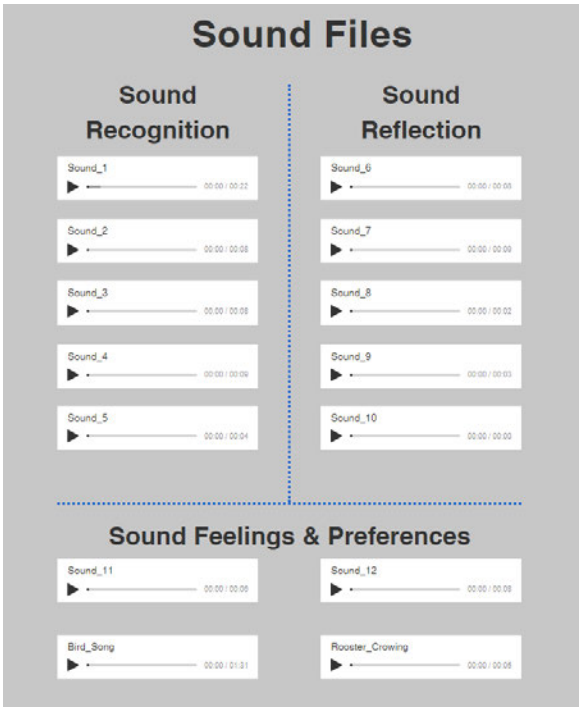

Figure 2. A screenshot of the external Wix webpage that hosted the sounds.

d. Instruments for Experiments:

For our experiment, we created a survey with the following questions. Many include a scale from 1 to 10 where users could rate their response rather than a simple like/dislike.

- What is your experience with sound in applications and websites? (scale: annoying/ enjoyable)
- For your phone notifications, how do you feel about having sound on? (always/ only for important stuff/ never)
- On a scale of 1 to 10, how important do you think sound is for the user experience?
- For the following sounds, please select the object that you believe makes that sound. (5 sound samples, 5 objects in a list)
- For the following sounds, please rate how willing you would be to listen to the sound again and what

action this sound means. (2 sound samples, Scale: Not willing at all/Very willing)

- What kind of action do you think this Sound # represents? (3 sound samples, Select/Start/Complete/Warning)
- How do you feel listening to this Sound #? (2 sound samples, Happy-Joyous/Goofy-Funny/ Sad-Depressed/Anxious-Panicky)
- Which of these two sounds do you prefer? (Songbird singing or rooster crowing)

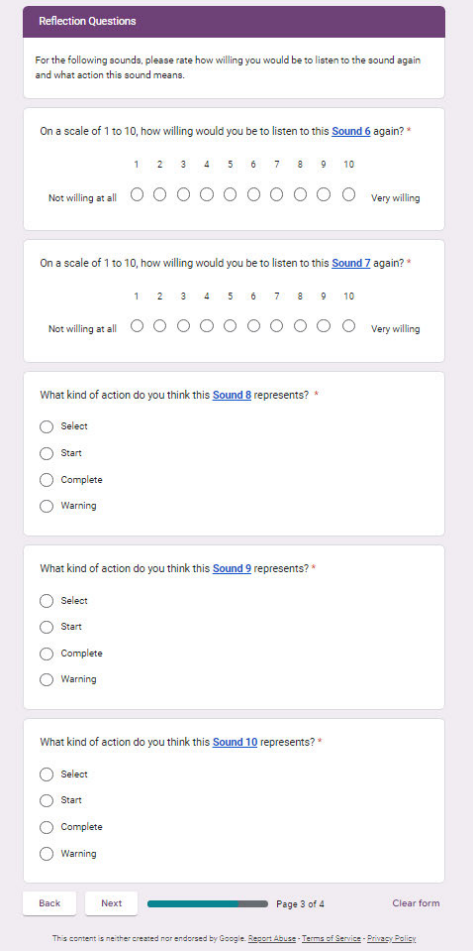

Figure 3. A screenshot of the third page/section of the survey form (aka "Reflection Questions").

e. *Procedure*:

In the first phase of the study, sounds were gathered from BBC Rewind, FreeSFX, and our own sources to be used for the survey. A variety of natural and synthetic sounds were selected to help us gauge the user's preference. From the studies we researched, the source of the sound should have an impact.

In the second phase, the Google Form was built for the experimental survey as well as the external website where the sound samples were hosted. Because of the limitations of both Microsoft Forms and Google Forms and the additional tendency of Google Drive to require a user to download a sound, the external website was the best and most versatile option.

In the third phase, the results were collected, graphed, and analyzed.

IV. RESULTS AND ANALYSIS

The results showed that participants were fairly mixed in their opinion of sound in their UI experience but leaned the same way when it came to being surveyed on recognition, reflection, and feelings and preferences.

In the first section of the survey gauging attitude towards sound, the overall participants' prior experience is vast and varied, but the number of participants that were on the lower half and upper half of the scale were both equivalent at nine individuals as shown in Figure 4. Regardless of how they found their experience with sound to be, most participants still found that sound is important in some way, shape, or form. As for participants' feelings on sound on for their phone notifications, a majority (55.6%) preferred to never have them on, while the rest of the participants (44.4%) only had

phone notifications on for important things. Despite there being a third option marked as "Always," no participants selected it as shown in Figure 5. This reaction to phone notification sounds is likely because of the principle that "Good design is as little design as possible," and that sound shouldn't be over-the-top or super repetitious because everyone has a limited repetitive tolerance [4]. In short, no one wants to hear the same notification over and over again for general notifications that don't necessarily need the user's attention at the time. They would only want it for the important stuff because that kind of thing requires immediate attention.

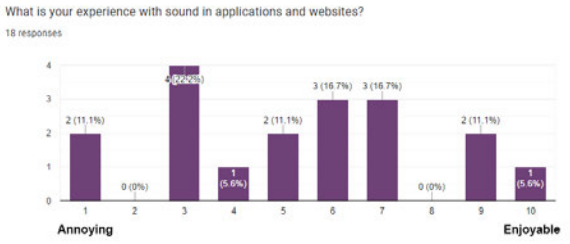

Figure 4. Graph of participant experience with sound in applications and websites.

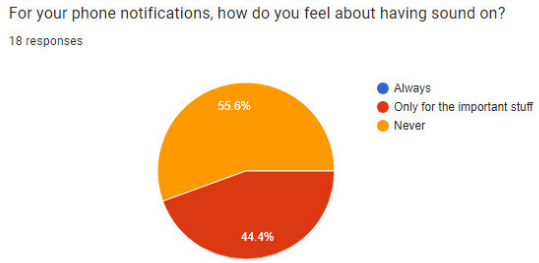

Figure 5. A graph of participant phone notification preferences.

Our survey results demonstrated that 96% of participants are capable of accurately identifying sound from the sound clips given to them as shown in Figure 6. In the article *A Survey of UI Sounds Used in Consumer Electronics and User Awareness*, consumers were found to accurately (70.8%) identify sounds and their meanings for those that they had heard before [2]. Although we weren't asking meaning for this section of questions all sounds were common sounds.

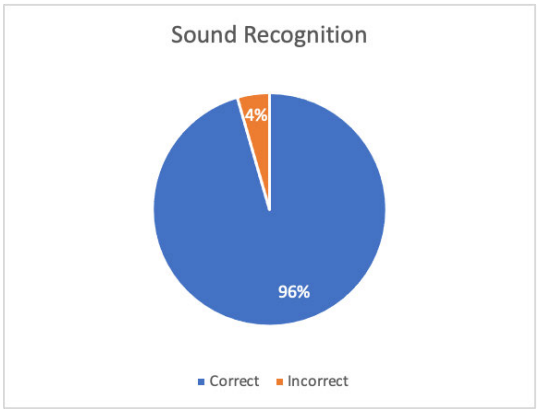

Figure 6. A graph of the overall accuracy of participants recognizing sound.

Participants showed a very clear adverse response to the fire alarm Sound 6 with 94% being less than willing to listen to the sound again (Figure 7A). Whereas 14 of 18 participants seemed to enjoy the flowing water sound and would be willing to listen to it again (Figure 7B). This seems to follow the results found by Aletta, et al discussed in the soundscapes article in our Literature Review section. Annoying and eventful sounds that feature abrupt or highly variable sound patterns elicit generally negative reactions whereas pleasing and uneventful sounds like the flowing water where the sound variation is minimal are generally said to elicit calming and positive emotions [8].

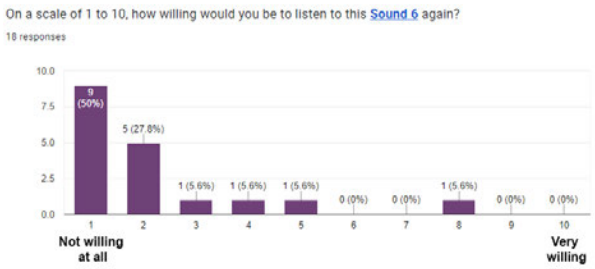

Figure 7A. Negative Response Trend for Fire Alarm Sound

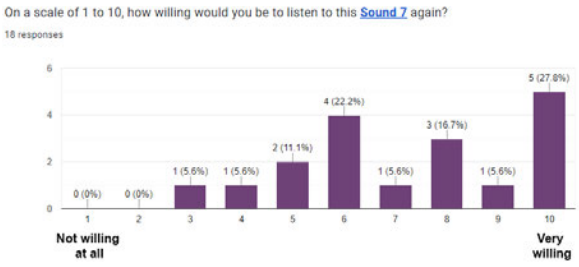

Figure 7B. Positive Response Trend for Flowing Water Sound

While Sound 8 and 10 have 83.3% of participants agreeing that the meaning of the particular sound can be used as a "complete" and "select" tone respectively. Sound 9 was evenly split between being a "warning" and a "starting" action prompt. See Figures 8A and 8B. It is important to note that Sound 8 and Sound 10 were sounds currently in use for their most prominently selected meaning. However, Sound 9 was a more ambiguous sound click from the song *Roundabout* by Yes, so it is not surprising that it received mixed results. This series of questions was designed similarly to that of the one shared by Wake, et al [2].

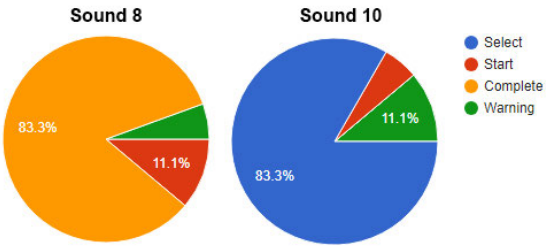

Figure 8A. Two graphs where sound meaning was more distinct.

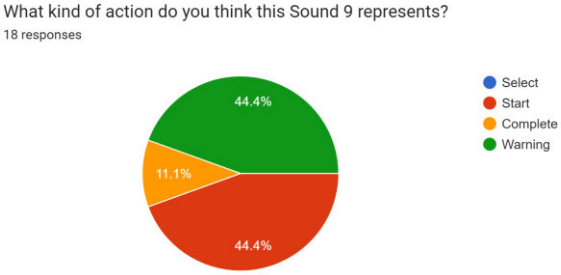

Figure 8B. A graph of a particular question gauging participant understanding of specific sound meanings.

It is important to note that participants exhibited clear preferences even between related sounds, like those of two types of birds. As shown in Figure 9, a generic bird song was preferred by 94.4% to the sound of a rooster crowing. As mentioned in the Auditory Preferences article by Tokue, et al, volume or "sound pressure" is shown to cause aversive responses in participants that could help to explain why the loud rooster crow was not the preferred bird sound of our participants [7]. The softer, more subtle songbird has a lower volume and is less abrupt in its sound variation.

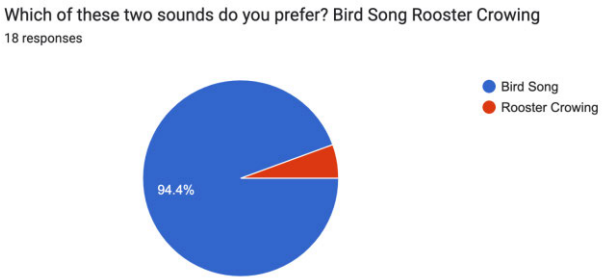

Figure 9. Participant preference between different bird sounds.

V. CONCLUSIONS & FUTURE RESEARCH

In conclusion, participants are able to accurately identify sounds. Meaning is able to be conveyed through sound, and those meanings are easily memorized by users. Sounds are also able to correlate to emotions and behaviors. Those with higher volume and sound variation trigger negative and aversive responses, while those with lower volume and less variation are found to elicit positive responses.

There is meaningful potential for future research in this area. There are a multitude of ways that one could go about doing this. However, we would recommend creating a couple of simple websites and utilizing the metrics available to see how users respond as well as having a feedback survey available for users. The website with more sounds may be muted or disabled sooner. Are there specific sounds that are confusing to users or cause an adverse reaction? While we have been able to show that generally louder and more synthetic sounds are less desirable, it would be nice to fine-tune that conclusion to specific volume levels and keys/tones.

ACKNOWLEDGEMENT

We would like to thank all 18 of the participants in our survey who - by design - have remained anonymous. We would like to apologize to those who knew that exact fire alarm sound, and we ended up subjecting them to it anyway. Katlin also has trauma from that specific sound.

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