DESIGN APPROACHES TO ALERT SOUNDS FOR INTERACTIONS IN SHOPS

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ABSTRACT

Shoplifting is a serious issue that causes loss to the retail owners. However, the loss can be avoided by adding preventative measures that could deter the shoplifters from committing the crime, such as surveillance and store design and layout. Considering that background music is a part of a store's design, this research combined surveillance and a store's design to discourage shoplifters by adding to or changing the background music to make the shoplifters feel observed, we asked if: 1) a change in background music could make the visitor felt observed, what are the possible design strategies? and 2) which design is preferable? Eight participants were asked to create a sound alert that matched an action of lifting an item in a shop mixed with various background music, document their design, and evaluate the sounds using adjectives. It was found that there were three main design approaches: altering, overlaying and altering-overlaying strategies. Preferences for alerts depended on the type of background music.

1. INTRODUCTION

Retail crime is a serious issue. As stated in a 2019 report from the Swedish Trade Federation (Svenska Handeln) [1], external thefts cause a loss of almost 6.9 billion SEK (700 million EUR) per year in Sweden in the retail sector alone. The loss from shoplifting is preventable and shoplifters can be deterred from committing the crime for example by employing trained staffs and installing a surveillance system. According to Ceccato et. al. [2], physical security measures are less effective, while different types of surveillance have larger impact. Most of the interviewed ex-shoplifters referred to "threat of being observed" as what discouraged them. Meanwhile, according to [3], the store design and layout is a primary deterrent.

There are different approaches at how to make people feel observed through the design of the store. If we consider the soundscape of a store as an element of its design, then perhaps using music and sound could be an answer. It is known that the background music of a store could influence the visitor's behavior. For example, it could affect the visitor's moving pace [4], product choice [5], and perception of the quality of the service and goods [6]. Knowing the influences that music has to human's cognition, we hypothesize that music could be used to influence a shoplifter's behavior as well. We would like to mix a subtle sound alert into the background music that could make the visitor's felt observed, without being intrusive and spoiling the shopping experience.

In this paper, we will mainly focus on the sound design that targets attention of people to the changes in the background music. Thus, we try to identify design strategies for sound design of changes in background music, and, in a scenario where there's a sound alert system that changes the background music according to the visitor's actions, we try to find preferable sound design.

2. BACKGROUND

In retail setting, there has been research about how the background music could influence the customer. Music with a slow tempo results in a slower movement pace than faster tempo, and slow music is also correlated to higher sales volume [7]. Unfamiliar music make customers perceive their shopping time as shorter than what it actually was than when listening to more familiar music [8]. The music played in a wine store affects the customer's choice: Playing German music increased the sales of German wine over French wine, while playing French music increased the sales of French wine [5].

Kellaris et. al. [9] argued that the studies about music and behavior are inconsistent and that some findings could not be replicated. Therefore, they dissected the effect of music by breaking it down to three basic properties: tempo, tonality, and textures/genre (where classical is "natural and acoustic" while pop is "synthesized and electronic"). They measured the effect of these properties towards pleasure, arousal, and surprise. Tempo affected pleasure and arousal, but was in turn influenced by texture (e.g., the effect tempo has on classical music is more prominent than on pop music). Tonality also affected pleasure and was influenced by texture. However, tonality affected surprise, but was independent of other variables.

In a study on the role of music taste on customer behavior and response, Sweeney et. al [6] found that liking of a type of music had larger positive effects on emotional responses than familiarity. However, there was also an independent effect from certain properties of the music: for instance, both fast classical music and slow pop music would increase the level of felt service quality and pleasure even for customers who did not like those types of tracks. The authors express caution in generalizing the results but claim that poor quality in service and merchandise may be compensated by carefully chosen music, and that higher levels of pleasure will give positive responses and behaviors such as reduced avoidance of other people.

Dubus and Bresin [10] studied the existing research on sonification and reviewed the mappings between physical properties and auditory dimensions. They found that the mappings often adhered to ecological perception. Kinematic properties are typically mapped to the pitch-related and temporal higher-level categories, and particularly rhythmic duration (sounds with duration between 100 ms and 2 s). The most common mappings for the individual categories of kinematics are location to spatialization and pitch, distance to loudness and pitch, velocity to pitch, and motion to pitch and spatialization. Additionally, horizontal movement is frequently mapped to spatialization, and vertical movement is mapped to pitch.

3. METHOD

Eight students involved with the Musical Communication and Technology course at KTH were participating in this research. One assignment was to design a sound alert. In the design brief, a video showing the interior of a clothing retail store was presented. It is a first-person view video, where the person walked around a store to pick up a jacket before hanging it back to the rack. The students were also given three background music tracks (BGM1–3) and one store soundscape that was to be mixed in with all backgrounds. The background music consisted of instrumental electronic pop music that are usually played in a fashion retail store, two of them have a pulsating rhythmic instrument playing in a constant beat (BGM1 and BGM2), while the third consisted of only ambient sound (BGM3). The soundscape is an atmospheric recording from a store – doors opening, clattering noise, and conversation. Both the video and the soundtracks have a length of 40 seconds.

The participants were asked to create a sound alert that matched the scenario depicted in the video. The sound should be subtle and match the three different background music. They should submit the sound alert mixed with the background and atmospheric noise, along with a documentation of their design. Afterwards, they were asked to fill in survey form evaluating the sounds that had been submitted. It was divided into six sections.

As described in Kellaris' work [9] the effects of music towards shopper behaviors are caused by the sound properties. Therefore, in the first, second and third section a quantitative survey method was used. In this survey, several criteria were proposed to rate the sounds. Those criteria are: noticeable, blatant, disturbing, fits the background music, fits the environment, and related to action.

The participants were asked if the sound fits the criteria with a 'Yes' or 'No'. The first three sections include the sound alert mixed with the three types of background music, in turn. To minimize order bias, the sounds in these sections were put in a random order for each participant. In the fourth section, the participants were asked if they could recognize the same sound across different background music. In the fifth section, the participants were asked to rate the best sound alert for each background music. In the last section, the participants described each sound design freely with three to five adjectives. The text documentation of their designs was analysed looking for keywords, and the design strategy for each sound design are synthesized from these texts.

4. RESULTS

The eight participants created one sound design each, denoted SD1–8. Each design was mixed in with the three different background music tracks, denoted BGM1–3. All respondents reported to have observed which designs that were identical across the different BGMs. The sounds designs and backgrounds are available for listening at http://smcresearch.se/annexes/2021-NSMC-PPA-KF.

4.1 Sonification Strategy

The following three main sonification strategies are synthesized from the submitted text documentations (see Fig. 1:a-c): *altering* the background music, *overlaying* the background music with another sound, or *altering-overlaying* which is a combination of both. The altering strategy includes changing the background music itself by for example adding a filter to subdue or amplify a certain frequency range or distorting the sound with a bitcrusher filter. The overlaying method includes adding an alert sound on top of the background music and mixing these. The altering-overlaying method combines these; usually, the participant would alter the background music through a filter and add another sound on top of it.

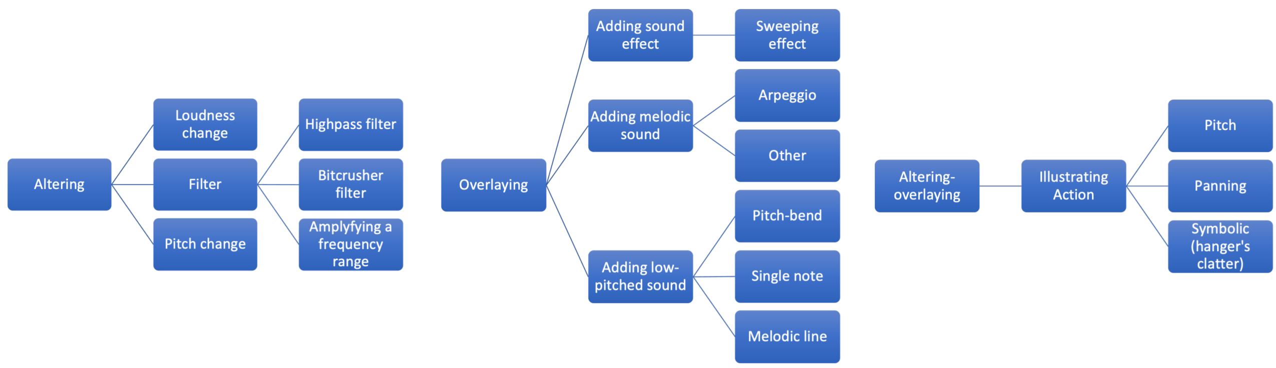
Out of the eight participants, only two participants explicitly stated how they attempt to match the sound and the action. SD4 maps the action to the physical and spatial dimension – using pitch increase and panning. Meanwhile, SD8 uses a symbolic sound of a clattering hanger, and pitch to denote distance. Descriptions of each sound design and strategies gathered from the written documentations are as follows: [1]

Sound Design 1 (SD1): altering-overlaying strategy I used the ES P synthesizer's noise generator and low pass filter in Logic Pro X together with automation of the cutoff frequency to create the sweep, gradually opening and closing the filter. The low cut and low shelf of a parametric EQ cut out the low end and lower the low mid-range to leave space for the BGM. A large hall reverb and a slow delay blend the sweep with the background.

Sound Design 2 (SD2): altering strategy The Graphic EQ in Audacity was used to amplify around 800 Hz with 13.9 dB and around 1.25 kHz with 5 dB. Then I raised the pitch with 2.0% and added a high pass filter at 500 Hz as this worked better on the BGM.

Sound Design 3 (SD3): altering strategy I used Logic Pro X to modify the BGM with high pass filters, a fuzz-wah, and a bitcrusher. The fuzz-wah created a wah-wah effect on the sound with a warm and soft

[1] The quotes are abridged and not verbatim.



a. Altering approach *b. Overlaying approach* *c. Altering-overlaying approach*

Figure 1. Schematic overview with examples of the altering, overlaying, and altering-overlaying design approaches.

distortion. The bitcrusher created a distortion from a drop in the bit rate mainly on the higher frequencies.

Sound Design 4 (SD4): overlaying strategy I used an A#0 bass guitar tone in Ableton Live to work with a low pitch for the alert sound. I applied a pitch bend, adjusted the tone and frequencies, added reverberation and subtle panning. I used Audacity to apply fade in/out and lowered the volume of the background as well as the alert sound. The mapping of the kinematics to pitch-related and spatial auditory dimensions follows our ecological perception.

Sound Design 5 (SD5): altering-overlaying strategy I created a sweeping sound in Ableton with EQ filter automation, moving from "all-pass" to low-pass during the 0.5 second noise sample. I automated a change in pitch (1 semitone) to the BGM during a 0.3 second interval. Lastly, I tweaked the track levels and the attack of the sweeping sound. The main idea was that the low-pitched sweeping sound would be attention-grabbing as low frequency sounds are sensed and felt throughout the body.

Sound Design 6 (SD6): overlaying strategy The notes C2 and G2 played at the same time on the "Classic Electric Piano" in Garageband. The attack gives it an alarm feeling and activates listening mode, but then fades out to reactivate the hearing mode. I applied panning to give the sound a wider feel as well as making it pulsate by panning one mono-track left-right-left-right and the other starting on the right, all within the length of the sound (approximately 3 seconds). "PlatinumVerb" was added to make it a bit more diffuse and blend in with the BGM.

Sound Design 7 (SD7): overlaying strategy I added sine wave sounds in Audacity which could both merge with and contrast the BGM, moving from a hearing to a listening situation. Since BGM1–2 are lounge music based on C minor, and BG3 is a constant soundscape around F#, I chose three notes which could create a chord with at least one tone in common and one not in common with the background. I made a rhythmic pattern in triplets which could both contrast BGM1–2's dual rhythmic pattern and add rhythmic information to BGM3.

Sound Design 8 (SD8): altering-overlaying strategy I slightly lowered the volume of the background music and added a clattering sound of a hanger with a simple low-pitched melodic line mixed in. Pitch increases and decreases to sonify the distance between the jacket and the shelves. The hanger sound was added to activate the listening mode, without being out of place because it is a part of a clothing store's soundscape.

4.2 Perceived Characteristic of Sound

The perceived characteristic of sound is defined as how the participant of the survey would describe the sound. It is related to the sixth section of the survey, where the participants were asked to describe each sound with three to five adjectives. Related keywords are grouped into one descriptor. For example, the word 'waving', 'swooping', 'sweeping', 'sweep', 'swoosh', 'wind', and 'airy' are all grouped into the keyword *swooshing sound*.

All the alert designs were described at least once by the criteria that were asked in the prior quantitative survey, for example the sound one was described as blatant three times, and sound five was described as subtle ten times.

4.3 Quantitative Survey Result

This section covers the result from the first, second, third, and fifth section of the survey. From the first to third section, the score was calculated. The criteria "blatant" and "disturbing" is considered as an undesirable characteristic and was given a negative weight. Afterwards, the scores were aligned with the "best sound" vote to see the correlations between them.

Generally, the score of SD1 and SD4 has the highest score across all the background music. This was done by counting the average score of the same sound design with different backgrounds. When the score of the sound with different background music was calculated separately, the result was different. With BGM1 the highest scoring sounds are SD1 and SD4, BGM2 is SD2, and BGM3 is SD5.

With BGM1, SD1 and SD3 have the most votes. While SD1 also has the highest score, SD3 scored below average. With BGM2, SD2 and SD3 have the most votes. SD2 has the highest score, but just like the previous case, SD3 was also scored below average. Finally, with BGM3, SD4, SD5, and SD7 have the most votes. SD5 has the highest score, and SD4 score was above average. However, SD7 has the lowest score but still have most votes. This shows that the score itself is not a reliable predictor of votes for best design.

4.4 Best Sound

Table 1 laid together the score across the seven categories, best votes, descriptors, and design strategy. The highest score for each column is highlighted in bold text, and the best voted are marked with stars. For example, the highest scoring sound alerts for BGM1 are SD1 and SD4, while the lowest scoring sound for BGM1 is SD7. Both SD1 and SD3 were voted as best.

Two of the sounds with most "best" votes used the altering strategy, while the other one used the overlaying strategy. Sounds that were rated high (having more 'best' vote) on BGM1 and BGM2 tends to be rated lower on BGM3 (e.g., SD1, SD4), and vice versa, the highest rated sound on BGM3 was rated low on BGM1–2 (SD5). Moreover, the sounds that are rated higher on BGM1–2 tends to have altering strategy, and the sounds that are rated higher on BGM3 tends to have overlaying strategy.

Two sounds that have most votes in BGM3 both have "subtle" as their key descriptors. However, the other sound that have most votes in BGM3 has the opposite adjective – "obvious", "loud", "alarming" – as its main descriptors. All sounds with overlaying technique that are candidates for 'best' in BGM1–2 share a similar feature: they were made of only one musical note (SD4 and SD6). Meanwhile, sounds with a relatively more complex melodic line (i.e., SD7 and SD8) have no votes in BGM1–2.

SD8, the sound that has no votes at all, has no distinct features. There is little agreement over its descriptors. While other sounds have at least one keyword occurring six times, SD8 has three keywords at most. Moreover, there is contrasting description. For example, the sound is described as "low-key" (which can be interpreted as "being in low frequency"), but also described as "treble".

5. DISCUSSION

5.1 Quantitative Evaluation

In this study, we scored the sound design with the seven criteria: "noticeable", "blatant", "disturbing", "has natural transition", "fits the background music", "fits the environment" and "related to action". However, how can we be sure that these criteria are relevant? Can we use this as a measurement for a good or bad sound design? It turns out that the high score does not necessitate best sound.

When determining the relevance of the criteria, we need to consider the weighing of our scoring system. The score of each criterion were given a weight of 1, except for "noticeable" and "blatant" which were given a weight of -1. It is plausible that the score does not reflect the quality because of an inaccurate weighing. In future studies, we could investigate which properties of the sounds that matter more, how they influence one another, and thus have a more reliable assessment of the sound. It is important to realize that we should not treat this as a conclusive evaluation of the sound given the small sample size.

5.2 Perceived Characteristic of Sound

How the descriptors are interpreted and grouped (cf. 1) relies heavily on the context. For example, "damp" is interpreted as "reduced in loudness" instead of "slightly wet" and is grouped into "muted". Another example is how "destructive" is grouped into "distortion" because the sound is also described as, among others, "scratchy", "harsh", "glitchy", and "distorted".

Another problem is that the respondents would use the criteria from the quantitative survey section to describe the sound, for example "subtle", "noticeable", and "background-fitting". Moreover, sometimes the respondents did not even use descriptive keywords, for example giving a link to a video. Finally, this survey also relies on the respondents' ability to describe a sound.

5.3 Sonification Strategy

Despite the small sample, we could categorize the result into three design approach – altering, overlaying, and a mix of both. We learned that there is a correlation between the type of the background music and the preferred sound alert. The background music that shared similar characteristics also have similar preferred alert. Some sound alert works better for one type of background music but does not work well with another type of background music, and vice versa. We could see a pattern where the altering approach is preferable for BGM1 and BGM2, while the overlaying approach is preferable for BGM3.

What could lead to this result? It could be assumed because BGM1 and BGM2 shared the same characteristic. They both has a pulsating beat, while BGM3 consisted of only ambient sound. To overlay the sound alert on BGM1 and BGM2 can disturb the original music, because it is possible that the sound alert will not match with the beat, adding noise, clashing with the leading sound, and drowned by the background music itself.

The mapping between movement and sonification is consistent with Dubus and Bresin's work [10], participants mapped the action with pitch, panning, and symbolic sound (hanger clattering).

What can we learn from this research to design the best sound alert? First, it was observed that there is a preference for simpler alert – e.g., pitch bend or just a single note. Meanwhile, the more complex, or rather, melodically varied, alerts are less preferred. For example, SD7 which is an arpeggio of three chord notes has lowest score across all background music and received no "best" votes on BGM1 and BGM2. Another example is SD8, which is a combination of a simple melodic line and clattering sound of a hanger. While the sound scored above average across all background music, it did not get any "best" votes at all.

Design	Scores and best votes				Strategy	Design method	Key descriptors
	BGM1	BGM2	BGM3	Total			
1	★ **78**	76	69	**74**	A-O	filtering removing high-frequencies adding sweeping sound	swooshing sound (9) blatant (3)
2	63	★ **80**	69	★ 71	A	highpass filter amplifying certain frequency	muted (6) lightness (5) subtractive (4) filter (3)
3	★ 53	★ 41	37	★ 44	A	highpass bit-crusher filter	distortion (8) alarm (5) noticeable (3)
4	**78**	78	★ 67	★ **74**	O	bass guitar pitch-bend A#0 mapping action to pitch	subtle (6) low-pitch (3)
5	67	63	★ **78**	69	A-O	pitch lowering adding sweeping effect	subtle (10) short back-forth sound (6)
6	67	59	61	63	O	low-pitch electric piano fade-out effect	ominous/dark (6) static (3) bass (2)
7	43	31	★ 35	36	O	D7 chord arpeggio	alarming (10) loud (4) obvious (3)
8	73	67	67	69	A-O	reducing BGM loudness clattering hanger sound melodic line	rhythmical (3) alert (3) quickness (2)

Table 1. Overview of the eight sound designs: score across categories (max 100, highest in bold), votes for best sound (starred), strategy (Altering, Overlaying or Altering-Overlaying), design method, and key description (keyword count).

However, one can also argue that the preference for a simpler alert is caused by the test condition itself. The video is only 40 seconds long and the lifting duration itself is only five seconds, thus limiting the diversity of the sound design, for example in terms of its length.

5.4 Limitations

Several of the limitations had been mentioned, i.e., the relevance of the quantitative evaluation's criteria and the context dependency of the sound's description. Other limitations will be discussed below,

The participants knew beforehand that there would be an alert when the hanger is lifted, and their answers are influenced by this. Therefore, the participants anticipated the alert, which may influence the survey result, especially for the "noticeable" criteria.

Another limitation is how the design is tied to this research's particular scenario. In a real setting, there would also be other factors influencing the perception of the alert, for example: the store's traffic, the ambient noise, etc.

The type of stimuli also might influence the result and can affect selective hearing (see e.g., [11]; research showed that visual, haptic, and visual-haptic stimuli performed differently. While our study regards attention grabbing rather than selective listening, one's focus is still directed to a certain sound, and there is a possibility that the modality of the stimuli could affect how people notice the sound.

The sound design is limited to the 5-seconds lifting duration. There is a possibility that some of the sounds will be disturbing when extended over a longer period. Furthermore, the design is limited to one object. Will the strategy work for multiple objects? For example, it is difficult to make alerts for multiple actions when we are using filters. As the participants are also describing and evaluating their own works, there could be a bias.

5.5 Future Research

This work presents opportunity to be developed in future research. While the qualitative survey offered richer information, such as how people would approach the design task, the quantitative survey suffers because of the lack of participants. The result was convergent to some degree. There are some observable patterns, but it could not be accepted conclusively. Bigger sample size could further confirm, but also disprove our theories as the observations we found from the qualitative methods are linked to the quantitative survey. For example, we observed that the best sound for the background track with only ambient sound (BGM3) uses overlaying-altering and overlaying strategy. However, the "best" sound was determined by the quantitative survey, which are lacking in sample size. Moreover, this study was not conducted with a realistic setting, which likely impacted the results.

This study could be replicated with bigger sample size and a more realistic scenario. The objective of having bigger sample size is not only to confirm the observable patterns, but also to collect more design strategies. By having more design strategies, we can find out if there are other approaches that have not been discovered yet.

The sound alert design was evaluated through its subjective characteristics. The participants were asked to rate the sound based on their own subjective thoughts, and then were also asked to make their own description of the sound. However, interpreting and grouping the descriptions is very context-dependent, and participants were not always able to properly describe the sound design.

The participants were directed as a course requirement to design a sound alert. Therefore, the option to use silence or silent gaps to attract attention was neglected. Even so, several of the design approaches utilize empty space by filtering out certain frequency ranges.

Negative spaces had been used in various design practices, and one of its uses is to attract attention. According to [12], silence activates auditory cortex, and in graphic design, one of the uses of negative space is to provide contrast to highlight the "differences between figure and ground" and "emphasize a certain element in a design" [13].

The designs are based on having only one object to sonify. In this study we discovered that altering the background music (e.g. using a filter) is a reasonable option. However, how can we make this work when there are multiple objects being lifted simultaneous or almost simultaneously? Can we use only one alert, or do we need one sound design for each object? Can one alert still be recognizable if other alerts are played at the same time?

Different types of background music require different approaches for sound alert design. Realistically, shops want to choose their own background music, which means that the alert should be tailored to any kind of background music that the store would be playing. There is an opportunity to research how to achieve this, for example by using machine learning to generate the suitable sound alert.

6. CONCLUSIONS

We identified three different approaches to sound design of alert sounds: overlaying, altering, and altering-overlaying. The overlaying method includes adding an alert sound on top of the background music, while altering method includes changing the background music itself (for example by adding a filter), and the altering-overlaying method is a mix of both (usually the participant would alter the background music through a filter and adding another sound on top of it). There were examples of matching the sound alert with the actions of the participant by mapping the action of lifting an object with for instance pitch change or panning. Actions were also illustrated by symbolic sound, such as the sound of clattering when a hanger was lifted.

Different background music leads to different preferences of sound design. From the results, a more "varied" background music tends to favor the altering strategy, while the more ambient background music tends to favor the overlaying strategy. Apart from the observable preferences towards the three design approaches, it was also discovered that a simpler sound alert is more preferred compared to a more complex and melodically varied sound.

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