Sonification of a radiator for sustainable energy consumption

Solbritt Gateman, Jiangyue Han, Amanda Lindqvist, Haris Vidimlic

Supervisors: Sandra Pauletto, Yann Seznec, Rod Selfridge

ABSTRACT

Radiators are generally designed and placed in a way as to not stand out in a room, which makes them often overlooked and therefore seldom associated with the energy consumption of a home. This paper researches how different sounds used as action-activated feedback when interacting with a radiator, can make people reflect on their energy consumption. A total of nine videos were generated by combining sounds, representing either negative or positive feedback, with the action of turning a radiator knob up or down. A survey was conducted where 15 participants were asked questions concerning whether the sounds made them reflect on their energy consumption and if they would accept them in their home.

Based on our results we hypothesize that acceptance in the home is a crucial aspect for creating sounds aimed at affecting a user's perception of a radiator's energy consumption. No conclusive evidence can be provided regarding which kind of feedback is the most effective. However, we speculate that sounds described as *smooth* and *natural* are preferred.

1. INTRODUCTION

There are energy-consuming appliances working quietly and out of sight in most homes. Since home appliances seldom communicate their consumption level, it becomes difficult to recognize and understand the amount of energy consumption at the time and over longer periods of time in particular. Implementing feedback systems in various devices could help consumers conceptualize their energy consumption in order to make more rational decisions regarding energy-related issues.

The concept of systems being implemented in different scenarios for the purpose of saving energy is not new (Asare-Bediako, Kling & Ribeiro, 2012). So-called Home Energy Management Systems (HEMS) have been on the rise for many years and are getting increasingly important. In a study by Nilsson et al. (2018), it was found that giving feedback to households about their energy consumption had a highly varying effect. Overall, feedback was not proved to make any remarkable positive changes. Later on, the report states the kind of feedback that people found most ineffective (Nilsson et al., 2018). One kind of feedback that turned out to be ineffective was receiving data expressed in unfamiliar or complicated metrics, since this made it difficult for consumers to make any connection to how much energy they were consuming. Another less useful approach was displays and apps that were interesting during the first few weeks, while later becoming less and less attractive to the users. A reason for the loss of interest could be that they would need to actively make their way to a screen or pick up their phone and start an application. This information could be used as an argument for exploring sonic feedback instead; the users do not need to interact with any external devices when using their appliances and there is no need to interpret any numerical data. Furthermore, sonification is familiar to users as it is used extensively in for example microwaves in homes and seat belt warnings in cars.

Previous work has studied the possibility of using sound to provide feedback on households energy consumption. Lockton et al. (2014) have, with a research through design approach in collaboration with UK households, explored and implemented a prototype of a sonification system. Through the use of birdsong, the system provides the household with direct ambient feedback on the energy consumption of appliances in the home. They used different bird species for each household appliance and the intensity of the birdsong correlated with the energy consumption. In the paper, they observed the importance of creating a sound that is accepted and fits in with the everyday soundscape of a household. They argue that birdsong is a ‘natural’, mostly non-intrusive sound that does not add to the collection of synthetic ‘beeps and bleeps’ people receive from other electronic devices. However, further research is needed as Lockton et al. (2014) did not test the sounds with users to explore whether sonification systems could aid in achieving acceptance from households whilst still promoting reflection and action.

According to the scientific experiments of Winters & Wanderley (2014) and Zhang et al. (2015), sound and music have proven to induce, deliver and regulate emotions. One of the major trends to interpret information from non-speech audio and music is using sonification, which can be natural sounds, synthetic sounds, or even noise. When it comes to utilizing sonification for energy consumption feedback, the challenge lies in using sounds in a way that still delivers the same message as other types of HEMS feedback; an awareness of one's energy consumption.

In order for sonification to convey this type of message without giving any scientific data, the sound has to indirectly invoke thoughts and feelings in the consumer. Our project aims to explore this and by incorporating elements from the previously mentioned research, it experiments with how different sounds and the way they are used can affect a user’s perception of the energy consumption of a home appliance. Radiators are an energy consuming appliance that we considered to be an interesting subject of the sonification experiment. We therefore devised a perceptual test to compare the effects of different sounds when used as action-related feedback for turning the heat up and down on a radiator. Another aspect of this was to investigate whether positive or negative feedback is more effective.

2. BACKGROUND

Radiators are an integral part of the heating system in many homes. According to Gyllensward et al. (2006), radiators are often placed out of the way in homes and people typically try to buy inexpensive radiators which in turn usually mean that they are less efficient. Considering this fact along with the quick and easy action of turning the knob without any particular feedback, makes radiators a great candidate for further development through sonification.

A sonic interaction concept presented by Serafin et al. (2011) is closed-loop interaction. They explain it as sounds that 'naturally' occur through interaction between the user and an interface, meaning that the user interacts with an interface which triggers a sound feedback that furthermore affects the user's action. They underline that the synchrony between sounds and gestures is an important part of sonic interaction as it strongly influences the perception of causality i.e. the relationship between cause and effect. They further emphasize the close connection between action and sonic perception and explain that the sound feedback should not set off a deep reflection in the user but rather be intuitive.

Similar research by Keysters et al. (2004) using monkeys showed that action along with an accompanying sound triggered a larger neuronal response than action and sound separately.

Sounds can often be difficult to define using words. With the aim of making it easier for sound engineers to communicate with other participants during a sound design process, Carron et al. (2017) created a sound lexicon consisting of 35 words describing different sounds, along with acoustic examples of each word.

3. METHOD

3.1. The sounds

The aim was to investigate if there is a possibility that using sounds in the interaction with a radiator could make consumers aware of their energy consumption. Creating the perceptual test consisted of finding or making potentially suitable sounds and applying this to the videos that were going to be shown to participants. Most of the sounds were found on websites offering free sound effects (BBC, Envato Elements, Pixabay) and then altered in regards to volume. Some sounds were created either by recording the sound of a certain action or by recording MIDI instruments in Garageband. The resulting nine sounds can be found in Table 1. Each sound was chosen with the intention of providing either positive or negative feedback. Positive feedback is meant to mediate to the user that the action of turning the radiator down will save energy, while negative feedback is meant to alert the consumer that turning the radiator up is increasing their energy consumption. The six unique sounds were also pairwise combined to first give negative feedback and then positive immediately after.

Table 1. All nine sounds with their name, type of feedback and a general description. The descriptions are only for reference here and were not given to the participants.

Name	Feedback	Description
1N	*Negative*	*Short, ticking sounds being repeated in an increasing speed while increasing in pitch*
1P	*Positive*	*Short, ticking sounds being repeated in a decreasing speed while decreasing in pitch*
2N	*Negative*	*Melodic, classical comedic sound, implying failure*
2P	*Positive*	*Melodic, synthesized, descending musical scale*
3N	*Negative*	*Environmental, match being lit and then fire crackling*
3P	*Positive*	*Environmental, rain on leaves with rainforest sounds, birds singing*
1NP	*Negative and positive*	*Sound 1N initially, then followed by 1P*
2NP	*Negative and positive*	*Sound 2N initially, then followed by 2P*
3NP	*Negative and positive*	*Sound 3N initially, then followed by 3P*

3.2. Making the videos

The next step was to record videos. The contents of the videos were the knob of a radiator being turned up or down several steps, as well as turned up or down in intervals of fewer steps. Editing of these videos was mainly done in iMovie. When applying the sounds to the videos, it was important for the sounds to be as much in synchrony as possible with the visible action of turning the knob. This was in order to create a closed-loop interaction in line with Serafin et al. (2011), since the intention was not for participants to question the timing of the sounds but rather being able to imagine themselves to be involved in the interaction happening in the video. All sounds were laid on top of the video clips right where the person's hand had grabbed the knob and was beginning to turn it. The sounds ended either as the action was completed or a moment afterwards. With the goal of further minimizing distracting factors in the experiment, the videos were made to all have a similar volume of the sounds.

3.3. Survey

The perceptual test was performed online as a survey, which was created using PsyToolkit (Stoet, 2010, 2017). A consent was required for participation and all data was collected anonymously. In the first part of the survey, the participants would state their gender, age and eventual hearing problems. They were then presented with nine videos, in randomized order, featuring either one or a combination of two sounds. Following each video, the participants had to specify their level of agreement to two likert statements, whether the sound made them reflect on their energy consumption and if they could imagine the sound being a part of their daily lives. The response scale consisted of seven points: strongly disagree, disagree, slightly disagree, neutral, slightly agree, agree and strongly agree.

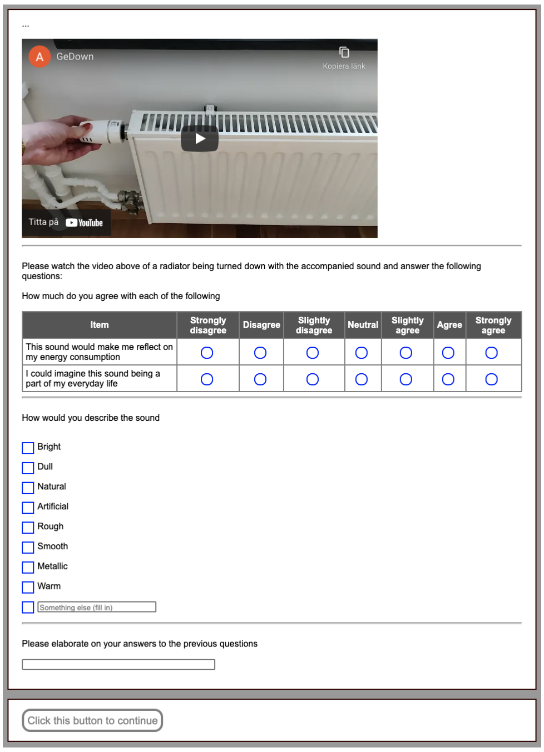

Figure 1. A screenshot of the online survey on PsyToolkit.com.

The participants were also asked to describe the sound using one or multiple of eight predetermined words, all of which can be viewed in Figure 1, and were given an option to include their own words. The eight words were picked from a sound lexicon that was created by Carron et al. (2017).

All of the first three questions of the survey were mandatory to answer. The fourth and last question was a voluntary opportunity for the participants to express their thoughts on the sound in free text.

The participants were not monitored when answering the survey and therefore had to use a computer and headphones before beginning the test. This was to ensure a similar testing setup for all participants. They were allowed to view the videos multiple times so that they could familiarize themselves with the sounds before answering the questions.

3.4 Data analysis

The last part of the study was to collect the anonymous data and perform statistical analyzes. Methods used for analyzing were mean value, median and standard deviation for an overview of the answers as well as Spearman's rank correlation. For the optional free text answers, a thematic analysis was conducted by thoroughly reading through them and highlighting general patterns. Tools used for the data analysis were Microsoft Excel and IBM SPSS Statistics.

4. RESULTS

4.1. Participants

A total of 15 people participated in the online test, of which seven identified as female and eight as male. All except one participant stated that they had no documented hearing problems. Seven people were within the age group 18-25, five people were between 26-45 and the remaining three participants were above 46 years.

4.2. Results of the likert statements

The participants' level of agreement to each of the likert statements was coded one to seven, where one corresponds to "strongly disagree" and seven to "strongly agree". The first statement concerned whether the sound made the person reflect on their energy consumption and the second statement if they could imagine the sound being a part of their everyday life.

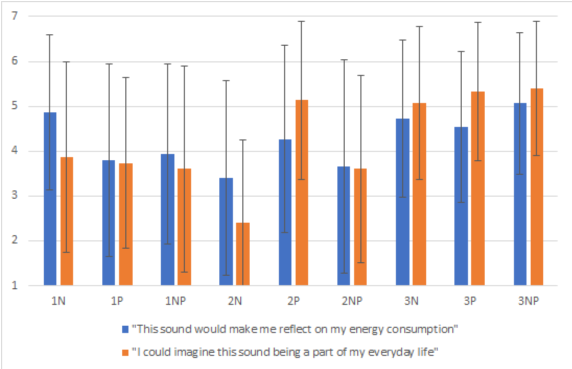

Figure 2. Average score of the participants to each of the statements

Figure 2 shows the calculated mean and standard deviation for each of the statements in relation to the nine different sounds. Sound *3NP* received the highest mean value for both the statements, the first statement had a mean of 5.1 and the second statement 5.4. The corresponding standard deviations are 1.6 and 1.5. On the opposite end, sound *2N* had the lowest mean value for both the first and second statement of 3.4 and 2.4 with standard deviations of 2.2 and 1.8.

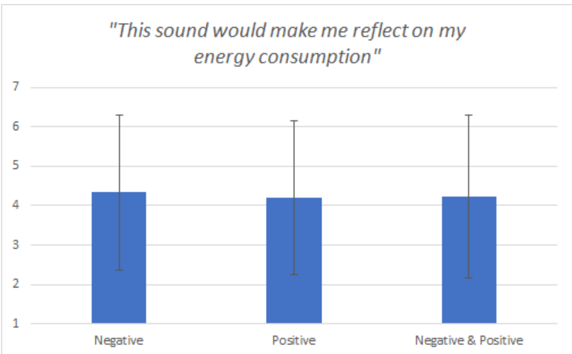

Figure 3. Average score to the first statement calculated for all the sounds in relation to the different kinds of feedback

The sounds aimed to give different kinds of feedback; positive feedback mediates that turning the radiator down saves energy, negative feedback alerts that turning it up increases the energy consumption and a combination of the two, i.e. negative & positive feedback. Figure 3 shows the mean value and standard deviation calculated for all sounds grouped by the different kinds of feedback. As apparent by the graph the values were close, the mean values were 4.3, 4.2, 4.2 for negative, positive and negative & positive feedback, respectively. With standard deviations of 1.97, 1.96, 2.07.

A deeper insight to the sentiments towards the different sounds, with regard to the two statements, can be seen in the comparative boxplots of figure 3 and figure 4.

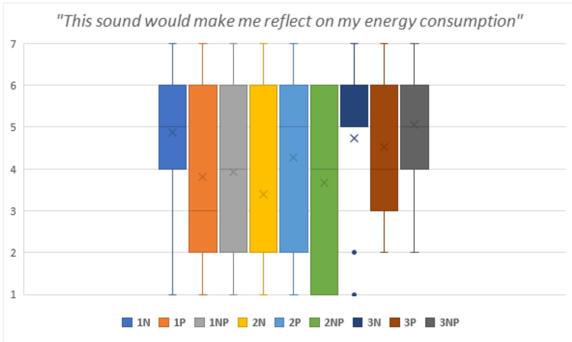

Figure 4. Comparative boxplots of each sound in relation to the first statement

Figure 3 shows we have a high dispersion for the majority of the sounds in relation to the first statement, *reflection on energy consumption.* The interquartile ranges, i.e. the ranges of middle 50% of the data, for sound *1P*, *1NP*, *2N* and *2P* are the same at 4 and fall within the same interval of 2 to 6 . Sound *3N* has the smallest interquartile range at 1, and a median value of 5.

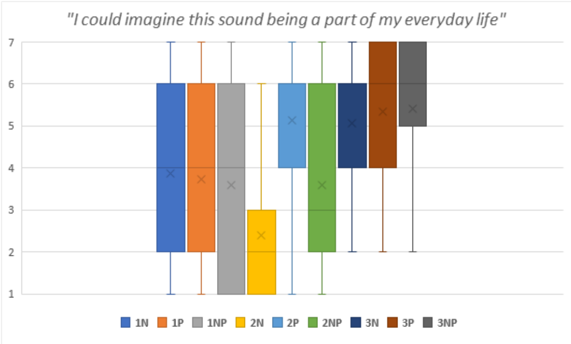

Figure 5. Comparative boxplots of each sound in relation to the second statement

A high dispersion can also be observed for many of the sounds in figure 4 in relation to the second statement, *imagine the sound being a part of your everyday life.* Sound *2P* and *3N* have the middle 50% of their data distributed between values 4 and 6. They furthermore have the same median value of 6 but with differing overall ranges of the data.

Table 2. Spearman's rank correlation of the two statements for each sound including correlation coefficients with the degrees of freedom and p-values

1N	positive correlation , ρ(13) = .89, p = .000
1P	positive correlation, ρ(13) = .58, p = .023
1NP	positive correlation, ρ(13) = .83, p = .000
2N	positive correlation, ρ(13) = .59, p = .021
2P	positive correlation, ρ(13) = .85, p = .000
2NP	positive correlation, ρ(13) = .67, p = .007
3N	*NOT statistically significant* ρ(13) = .37, p = .173
3P	positive correlation, ρ(13) = .73, p = .002
3NP	positive correlation, ρ(13) = .56, p = .032

A spearman's rank correlation was computed for each of the sounds to evaluate the relationship between the two statements, i.e. if the sound made people reflect on their energy consumption and if the sound could be imagined as a part of their everyday life.

As seen in Table 2, the spearman's rank correlation shows a statistically significant and strong, positive relationship between the two statements for each of the sounds with the exception of sound *3N*. Sound *3N* did not show a statistically significant association between the statements and therefore we can not reject the null hypothesis that there is no correlation.

4.3. Descriptive words and free text box answers

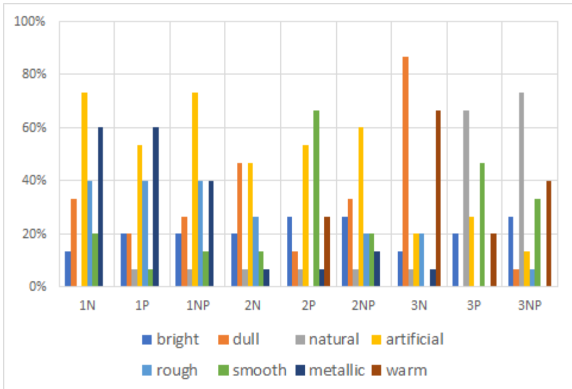

Figure 6. The percentages of participants selecting the different predetermined words to describe each sound

Figure 6 presents percentages of responses for each of the predetermined descriptive words in relation to the different sounds. The results most agreed upon can be observed with sound *3N* being described as *dull* by 87% of the participants and 73% describing sound *1N* and *1NP* as *artificial* and sound *3NP* as *natural.* In addition the participants had the option to include their own words. Sound *2N* and *3P* was described as *comedic/funny*, sound *2N* and *2NP* as *awkward/confusing,* sound *2P* and *3N* as *pleasant.* The word *cosy* was also used in relation to sound *3N.* The words *piercing/high pitched* and *chilling (to the bone)* were used for sound *1P* and *1NP*, respectively.

In the optional text box answers, the participants gave their general thoughts on the sounds. All answers can be found in Appendix A. There were both positive and negative feelings expressed towards the sounds themselves. The three environmental sounds (i.e. *3N, 3P* & *3NP*) were the only group of sounds that did not receive any negative comments. Some participants stated that they liked parts of the sounds, but that some other parts were uncomfortable to listen to. One sound, *2N*, received particularly negative comments. The sound itself was generally not liked and it was frequently noted that the message that was perceived was different than what contestants believed was intended.

Some other sounds did have the effect of notifying that something was increasing or decreasing, but did not give the intended associations. A common theme for several sounds was that participants expressed that the sound made them think of heat, but not of the environment and the environmental effect connected to the action. One participant stated the following about sound *3N*: *"I think it connects more to increased heat than to increased energy consumption but a nice sound."* Sound *3P* received several comments where participants stated that the sound made them think of the environment.

5. DISCUSSION

5.1. Methodology critique

Individual participants sometimes gave inconsistent answers for the same sound, which could be a consequence of sending out surveys virtually. Answering the survey might have been rushed by some participants and this is hard to control when letting people participate in their own time. It might also be that they were disconnected from the experiment in a way that caused them to be less thorough when answering. This could potentially have been prevented by having the participants do the test in person.

Another considerable advantage with doing a physical test would be that the participants could have been able to take part in the interaction themselves. If they would have heard the sounds as they were turning the knob of an actual radiator, the results might have been different and more accurate. Yet, making a working prototype for this sonification would have been too complicated for our timespan. Therefore, a video format probably provided the most sense of realism and synchronization that we were able to produce in this project.

5.2. Result analysis and future research

The results from the first likert statements clearly show that from this study, we cannot interpret whether positive or negative feedback is the most effective at triggering reflection. Moreover, defining negative and positive feedback is highly subjective. The type of feedback that we believe participants perceived can therefore only be decided by which action a sound was tied to. In other words, it might be that some participants did not consider the sounds for turning the knob up and down to actually convey negative and positive feedback respectively. It could also be that, because all sounds were different, they rated only the sound itself without any regards to the type of feedback. These could potentially be reasons for the scores being almost similar for *N, P* and *NP* (see figure 3).

For some of the sounds, participants expressed that they experienced other associations than energy consumption or even the environment. For example, some commented that they connected *3N* to the heat being turned up since the sound reminded them of a fire. This reveals the important topic of sounds possibly being too closely related to the nature of the appliance. We speculate that it might be necessary that sounds are distant enough from the function of the appliance that they induce a new thought process in the user, rather than just confirming something they already know is happening. However, there were also results indicating that a number of participants thought that some sounds were too foreign for the situation: *"[...] does not feel like a sound a radiator should make."* This can be an example of when a sound causes too deep of a reflection, which according to Serafin et al. (2011) does not create a closed-loop interaction. In order to achieve a closed-loop interaction as well as causing the user to reflect on the consequences of their action, it is important to further experiment on finding a balance between novelty and familiarity.

As apparent by figure 4 and 5, the sentiments towards the different sounds in relation to the two likert statements had a high dispersion. This was furthermore reflected in the arguably discrepant words used to describe the different sounds (see Figure 6). The latter could be a confirmation of the difficulty in describing sounds with words. Future research could consider including acoustic examples in relation to each word (Carron et al, 2017). Another reason for the wide distribution of the results could also be the relatively small participant group, N=15. Conversely, the results could indicate that people do in fact have differing opinions and views on which kinds of sounds are most appropriate at conveying energy consumption. A possible development would therefore be to examine whether sonification of home appliances for energy consumption should allow the users themself to choose the sounds.

Nonetheless, we can observe some patterns in our results. As mentioned in section 4.3, the three environmental sounds received exclusively positive comments in the text box answers. Figure 2 shows that they (*3N, 3P, 3NP*) have among the higher means along with a low standard deviation, indicating that they are among the more suited sounds for our implementation according to the survey.

Sound *2P* is another sound with high means and somewhat low standard deviation, likewise indicating that it is one of the more successful sounds in this experiment. One text box comment described *2P* as *"[...] bubbly-ish [...] made me think about water and nature".* Therefore, it can be argued that natural, environmental sounds seem to be best suited for this kind of implementation. However, sound *2P* received several *artificial* votes which somewhat contradicts the text box answer. *2P* also received several *smooth* votes. This could indicate that the best sounds for similar applications are smooth and natural sounds. Future research regarding sonfication and increasing awareness of energy consumption could therefore focus more on sounds that are considered smooth and natural.

Based on the graph in Figure 3, there appears to be a connection between the level of agreement to whether the sound made a person reflect on their energy consumption, and if it could be imagined as a part of their everyday life. Further examination by spearman's rank correlation (see Table 2) confirms that there exists a strong positive relationship between the two statements for each sound utilized in this study, with the exception of sound *3N.* This indicates that if a sound is perceived as being too intrusive in the home it counteracts its potential to evoke reflection concerning energy consumption. Conversely, it also implies that sounds that are welcomed in the home and thought unobtrusive, consequently have more potential to make people reflect on their energy consumption. This notion is consistent with and expands upon Locket's et al. (2014) observation of the importance of creating an accepted sound that fits within the everyday soundscape of a household. We hypothesize, based on our results, that acceptance in the home is a crucial aspect of sounds aimed at affecting a user's perception of the energy consumption of a home appliance. However, future research on other types of sounds is needed to further explore this hypothesis.

5.3. Project assessment

The overall project has proceeded well and mostly according to plan. We had some problems related to the survey that did delay our work in relation to the timeplan. One aspect was a lack of research on the survey tool prior to creating the survey. This resulted in us having to redesign it in another tool since the one we started to use did not meet all our requirements. Another big aspect that delayed our collection of data was that participants experienced trouble with loading the videos. This caused us to have a big number (N=8) of uncompleted surveys.

After this project, we all feel like we have learned more about conducting perceptual tests. One thing that stood out to us is that results from a perceptual test with different participants is difficult to quantify, since perception is something highly individual. It was also complicated, or rather impossible, to create equal experiences for all participants, especially in an online test.

One of the strengths of the project was that we stayed dedicated to the project plan. Problems with differing schedules were negated by frequent online group meetings, where we divided and delegated the work.
In hindsight, it would have been good to put more emphasis on a pilot study, as we lost several respondents' data due to technical issues. More time for data collection would have compensated for the technical issues.

6. References

Asare-Bediako, B., Kling, W. L., and Ribeiro, P. F. Home energy management systems: Evolution, trends and frameworks. *2012 47th International Universities Power Engineering Conference (UPEC)*, 2012, pp. 1-5, doi: 10.1109/UPEC.2012.6398441, https://ieeexplore.ieee.org/document/6398441

BBC, ©2021. https://sound-effects.bbcrewind.co.uk/

Carron, M., et al. "Speaking about sounds: a tool for communication on sound features." Journal of Design Research 15.2 (2017):85-109.https://www.inderscienceonline.com/doi/abs/10.1504/JDR.2017.086749

Envato Elements, ©2021. https://mixkit.co/free-sound-effects/

Gyllensward, M., Gustafsson, A., & Bang, M. 2006. " Visualizing energy consumption of radiators ". In International Conference on Persuasive Technology (pp. 167-170). https://www.researchgate.net/publication/220962595_Visualizing_Energy_Consumption_of_Radiators

Keysers, C., Kohler, E., Umiltà, M.A. *et al.* Audiovisual mirror neurons and action recognition. *Exp Brain Res* 153, 628–636 (2003). https://doi.org/10.1007/s00221-003-1603-5

Lockton, Dan, et al. "Bird-watching: exploring sonification of home electricity use with birdsong." *Conference on Sonification of Health and Environmental Data*. 2014. https://www.researchgate.net/profile/Dan-Lockton/publication/265008983_Bird-Wattching_Exploring_Sonification_of_Home_Electricity_Use_with_Birdsong/links/53fb5d520cf22f21c2f31281/Bird-Wattching-Exploring-Sonification-of-Home-Electricity-Use-with-Birdsong.pdf

Nilsson, A., Wester, M., Lazarevic, D., Brandt, N., "Smart homes, home energy management systems and real-time feedback: Lessons for influencing household energy consumption from a Swedish field study," Energy and Buildings, 2018, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2018.08.026.

Pixabay, 2021. https://pixabay.com/sv/sound-effects/

Zhang, R., Jeon, M,. Hyuk Park, C., and Howard, A. 2015. "Robotic Sonification for Promoting Emotional and Social Interactions of Children with ASD." In <i>Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended, *Association for Computing Machinery*, New York, NY, USA, 111–112. DOI:https://doi.org/10.1145/2701973.2702033

Serafin, S., Franinovic, K., Hermann, T., Lemaitre, G., Rinott, M., and Rocchesso, D. (2011). "Sonic interaction design." In Hermann, T., Hunt, A., Neuhoff, J. G., editors, The Sonification Handbook, chapter 5, pages 87–110. Logos Publishing House, Berlin, Germany, https://sonification.de/handbook/download/TheSonificationHandbook-chapter5.pdf

Stoet, G. (2010). PsyToolkit - A software package for programming psychological experiments using Linux. *Behavior Research Methods, 42(4),* 1096-1104.

Stoet, G. (2017). PsyToolkit: A novel web-based method for running online questionnaires and reaction-time experiments. *Teaching of Psychology, 44(1),* 24-31.

Winters, R., & Wanderley, M. (2014). "Sonification of Emotion: Strategies and results from the intersection with music." *Organised Sound, 19*(1), 60-69. doi:10.1017/S1355771813000411. https://www.cambridge.org/core/journals/organised-sound/article/abs/sonification-of-emotion-strategies-and-results-from-the-intersection-with-music/4DAB6EB56F135B8940608330BF96FA17

Appendix A.

Table A1. The comments from different participants given in the free text boxes for each of the sounds.

Sound	Comment 1	Comment 2	Comment 3	Comment 4	Comment 5	Comment 6	Comment 7	Comment 8
1N	Sounds like a bomb going off. I guess this would stress me out more than do good	I think it both gives a connection to something becoming more intense, so I think it connects to energy but also to heat.	The sound itself isn't harsh, but I find it to be too soft to imply something negative.	I don't really want to turn the heat up haha..	Like the previous question, sounds like radioactivity. However, this time it sounds more lethal the more you turn up the radiator (better?)			
1P	This was much more clear than the turn up turn down video. Editing mistake maybe?	'sounds like im choking a cricket	Perceived as a clear reduction with a connection to some type of energy, good	I find the sound in the beginning to be piercing, and it does get the point across as the sound gets less high pitched and more pleasant, which would probably be an incentive enough to lower the heat.	The decreasing rate of *beeps* make it feel as if the energy consumption is lowered, I like it.	Sounded too artificial and I cant really connect it too the nature than in some kinda battery.		
1NP	I think the sound is good but might be misleading as the turning down part doesn't start where the turning up part started	Simple and clear	I find this one to be a little confusing as it ticks slowly on the way up and faster when going down.	Turning it down felt inconsistent with turning it up? But I get the idea I think	It reminds of radiation and geiger counter	Sounds almost like one of those devices that measure radiation activity. Turning the radiator down sounds like you are getting a lethal dose, probably the opposite of what you'd want.	Sounded like some kinda battery	
2N	It made me think if I did something wrong, if it was wrong to turn up the heat, so yes, indirectly it made me think about the environment I guess	"Im a loser for feeling cold" - wrong message I reckon	Made me think "I'm doing something wrong"	I really cannot stress how much I don't like this sound. But maybe that is the point... I feel as if it would make people feel *really* bad if they heard this	The sound itself does imply failure and that something is wrong but I wouldn't like hearing it a lot. Maybe that's the point, I'd keep the temperature low	It felt like it was wrong to turn the heat up, but that it has to do with energy consumption wouldn't be my first	Feelt really artificial but clear with its meaning	Just annoying

				sound every time they turned on the heater. I feel as though the "ticking" sounds that go up/down in frequency do a better job of reminding you of the cost of heating.	so I wouldn't be reminded of my failures.	thought I think		
2P	Felt like something right was done	Sounds like powering off a mac or Wally - comfortable but not assoicative of saving energy	Nice sound does not connect to energy consumption	I like this sound the most thus far.	Felt like it was the right thing to do and sounded slightly like a bubbly-ish-sound so it made me think about water and nature	This sound is more like positive feedback than the others. I feel as if positive emotions are better suited for this than negative emotions. Still, the "ticking" sounds are a good mix of the two.	I liked it simple and clear with a warm touch	
2NP	So I lose by turning on the heater then turn on my mac?	I do not like the trumpet and do not connect to energy consumption	I like that the sounds are light-hearted. The fail sound would make me wonder what I've done wrong and the sound as the heat turns down is nice.	The bubbly sound made me think about the enviroment and the waa-waa sound made me think about that turning up the heat was wrong	The first sound (when turning the radiator on) does not feel like a sound a radiator should make. I really liked the second one though, sounds like you are doing something positive.	More clear than the others and quite rough		
3N	Very nice sound, but could be confused with "turning up the heat"	Comfortable sound - though it does not make me think of my consumption	Very pleasant, but the sound mostly confirmed the fact that I was increasing the heat	I think it connects more to increased heat than to increased energy consumption but a nice sound	This sound is quite cosy. Since the theme is environmental impact from increased energy comsumption it does also make me think of a burning forest, so it does get the point across. Also makes me want to cosy up with a blanket. :)	Very pleasant sound but it might get mixed up with the thought that the heat was being turned up and so the fire gets "bigger"	The initial lighting of the match was a bit much, but otherwise I liked the increase in intensity the higher the setting.	Sounded really artificial

3P	I like this one, would turn down the heat just to hear it	It made me smile. I guess since Im watching you turn down the radiator it does make 'less warmth + sound of the amazom' -> turn into a more concious consumer - me	Made me think that I was decreasing the heat	I get no connection to increased energy consumption	I like this sound, it's really calming and refreshing. It would make me happy to hear it.	This does not feel like a sound a radiator should make. To me, it sounds a bit tropical, so I'm not sure why it would play when I'm turning the heat down.	I feel like the sound made turning radiator more meaningful in a way because it made me think a lite more about what you actually are doing to the nature by turning it on.	
3NP	The up sound made me think that I was making the room warmer, but the down sound made me think about the environment thanks to the birds and "jungle" sound	the key is the amazon forest sound - makes me think green	The bird sound when turning it down made me think of the environment, the fire, again, mostly that I was increasing the heat	Gives a clear message but thinks the sound can be annoying	The sound of crackling fire does imply the negative aspect of increased energy consumption, but I also find this one to be too soft and cosy to imply this. The forest sound is pleasant so I would probably want to hear it more than the fire.	I really liked the sound when turning down. The birds made me think about the environment, the fire, fire mostly that it was getting warmer in the room	The two sounds don't really mix all that well. I prefer the ticking sounds due to them more naturally adapting to "turning up the heat" and "turning down the heat"	The sad truth