Emotions in sound design: exploring emotions in knocking sounds

Malcolm Houel
970218-T497
mhouel@kth.se

Abhilash Arun
970630-T257
aarun@kth.se

Alfred Berg
900922-3158
alfrberg@kth.se

Alessandro Iop
960916-3234
aiop@kth.se

***Abstract*—Can knocking sounds play a role in our perception of emotions? And can the properties of these sounds have an impact on our emotions? We aim to address these questions in this study through a recording session and a perception test. Based on previous research, we then describe the methodology used to record knocking sounds with different emotions. Finally, we discuss our results showing that some recordings are significantly affecting emotional judgement, and that physical properties, such as loudness or knocking frequency, differ between emotions.**

***Index Terms*—Emotions; Foley sounds; perceptual experiment; emotional judgement; recording session; knocking patterns; acoustic features; survey; statistical analysis.**

I. Introduction

Knocking sounds are an important tool in storytelling for many media platforms such as games, films and short stories. These sounds can tell us a lot about the person who is knocking at the door. Knocking sounds can also act as a mode of communication between the people on both sides of the door. The intriguing fact is that there are a various number of knocking patterns. The knocking patterns used in a positive scenario might differ from the patterns used in a negative scenario. Furthermore, these patterns might also differ from one person to another even if it's the same situation. Therefore, different knocking patterns are used in different types of situations.

The aim of our experiment is to explore the different emotions expressed in the knocking sounds. Understanding how these emotions are communicated through the sounds might eventually help researchers and developers to incorporate these sounds in real time media, such as games or animations. The recording session involved six participants from different cultures and focused on five primary emotions, or states of mind: anger, sadness, fear, happiness, neutral. The emotions were presented to the participants in the form of scenarios; they were then encouraged to imagine themselves in those scenarios and had to knock on the door. After collecting the recorded sounds, a perception test was conducted to analyse and study the recordings; the goal was to find out which ones successfully communicated their intended emotion.

We referred to Emotional Cues in Knocking Sounds (Vitale and Bresin, 2008) [1] to gain ideas and insights from their experiment; it is one of the very scarce studies conducted on the role that everyday sounds play in the communication of emotions. We followed a similar set-up to obtain our recordings but focused on different parameters while designing the perception test. We hope that our experiment can do justice to this field of research by providing a strong basis for future research.

II. Background

Several experiments have been conducted to explore the capacity of human perception to infer characteristics of the sound source. Li, Logan and Pastore [3] have shown in their experiment that humans are able to extract information from everyday sounds such as being able to tell the gender of someone who is walking. Spectral parameters have also been identified as audible cues for the "maleness" judgement, for example the spectral peak and frequency slopes. In another study, Mcadams, Chaigne and Roussarie [4] revealed how mass density and length of hitting objects could influence our perception of the resulting sounds.

By extracting the parameters of a given interaction such as the spectral mode of an impact-based sound, we can create artificial sounds indistinguishable from the real ones, as claimed in Barahona and Pauletto's study [5]. In their experiment the resonance of four different materials was analysed. Interviewed people were unable to recognize artificial sounds from recorded ones. Previous scientific studies have explored the music mechanism and our perception of music: Giordano and Mcadams [7] show a correlation between the timber perception and the source mechanism, while Lindström, Juslin, Bresin and Williamon [8] claimed in their questionnaire that musicians consider expressivity as the main skill in music.

A great deal of research has been done in the field on emotions in music and walking as well as basic emotions in general. But, in contrast, little research has explored environmental and everyday sounds. As previously mentioned, Vitale and Bresin analysed relevant parameters in knocking sounds in their study. Their perception analysis was focused mainly on the parameters like Inter-Onset Interval, number of knocks and perceived loudness.

III. Method

The aim of the study is to identify possible correlations between the emotional content and the acoustic features of knocking sequences. In order to find such correlations the study was structured around four interconnected steps:

- record emotionally loaded knocking sequences;
- test whether the knocking sequence can successfully convey the intended emotion;
- analyse the acoustic features of the knocking sounds;
- find correlations between acoustic features and perceptual ratings of knocking sounds.

A. Recording session

The recording sessions were carried out on a single day in a semi-soundproof room (Multistudio, room 4632, D-huset, Lindstedtsvägen 5, 6th floor, KTH campus) sized 27 m^2. The knocking sequences were performed and recorded on an MDF door measuring 203.7·72.6 cm, using a *Røde NTG2* super cardioid shotgun microphone with 76dB SPL signal/noise ratio along with a *Zoom H4n Pro* recorder; the sample rate was 48 kHz, the depth was 32 bit.

Three men and three women, aged 23.16 on average (1.72 years standard deviation) from different countries (Germany, India, Italy, Serbia, USA), were selected amongst naïve friends of the group members. Each participant was asked to specify an area on the door where they felt comfortable knocking, the microphone was then placed 35 cm from the center of the specified area. After an introduction and a test recording, the participants were told to knock according to a scenario which was aimed to evoke a specific emotion/given a scenario aimed to evoke a specific emotion and told to knock in a way that reflected the scenario, for example: sadness was meant to be evoked by presenting a scenario to the participants wherein had to tell their best friend that he/she had decided to move to another country and therefore would not be able to see them in the future. Every participant recorded a total of 20 knocking sequences for each of the five scenarios for a total of 600 sequences. All instructions were given vocally and the participants received no payment for their contribution. See Appendix I for detailed descriptions of the scenarios and pictures of the recording setup.

B. Perception test

For the perception test, five recordings were selected for each emotion in order to keep the duration short and keep the respondents focused. The initial set of knocking sequences was first reduced so that only recordings that satisfied certain criteria, related to time and lack of external noise factors, remained. Moreover, the tracks included in the survey were selected randomly from this set, making sure that not more than one of them were produced by the same participant. This meant that, for each emotion, one of the participants was not represented.

The test was carried out using an online survey tool called *SoGoSurvey* [9] and the participants were recruited by forwarding the survey link to friends and families of the group members via social media. As mentioned above, the survey contained 25 knocking sequences (five per emotion) presented in a random order. Before the recognition-part of the test, participants reported their age and gender. They were also encouraged to use headphones and adjust the volume to a comfortable level. After each knocking sequence the participants judged the emotional content by selecting one of the five emotions. The emotions were displayed as a horizontal line of radio buttons and the order of the emotions was randomised for every knocking sequence.

C. Acoustical analysis

In parallel to the perception test, we carried on an acoustical analysis of the 25 clips proposed to respondents using *Adobe Audition*. For each recorded knocking sound, the features we focused on were:

- number of knocks in the clip;
- global frequency of the clip, which is the average frequency measured in Hz;
- maximum and average RMS amplitudes in dB SF (not in dB SPL because we have no control over how sounds were played by the respondents to the survey);
- ITU-R BS.1770-3, a standard for television broadcasting in LUFS, which estimates the perceived loudness and is preferred to the RMS amplitude since it is not affected by silence periods;
- duration in seconds, measured from the onset of the first knock to the onset of the last one (and therefore excluding the last knock of the clip);
- knock frequency in knocks per second;
- IOI variation, which is related to the pattern of knocks in the clip and its variability.

For each of such acoustic features, the average value, the standard deviation and the 95th percentile were computed grouping clips by emotion as well as considering them all together. The aim of the entire analysis was to find relevant trends for different emotions, estimating their variability and assess which ones could potentially be more easily distinguished (and therefore recognised) by people.

IV. RESULTS

A. Perception test

The online survey was completed by 98 respondents and a total of 2450 answers were recorded. Two participants did not complete the survey and were excluded from the data. “Neutral” was the most chosen answer (29.8%), followed by “angry” (26.1%), “frightened” (15.8%), “happy” (14.6%) and “sad” (13.8%). Of the knocking sequences, two angry, two sad, one happy, one neutral, and no frightened were correctly identified as the intended emotions more than 50% of the time. Data from the survey was analysed via a chi-square test for independence in *IBM SPSS Statistics 26*. The relation between knocking sounds and people’s judgments was highly significant, $\chi^2(96, N = 2450) = 2277.58$, $p < 0.001$, indicating that people are indeed able to infer the emotion of a knocking person from the acoustic properties of the knocking sounds. Of the knocking sequences included in the present study, all emotions except the frightened one had at least one knocking sequence that significantly more people than expected judged as the correct emotion. For example, when the fourth knocking sequence corresponding to anger (*A4*) was played, significantly more people chose the “angry” response (81.6%) than would be expected if no significant relation between knocking sequences and judgements existed (29.8%). This was also true for three of the knocking sequences corresponding to fear (*F2*, *F3*, and *F5*). Some knocking sequences generated significantly fewer responses than expected for certain emotions, for example the fifth knocking sequence corresponding to happiness (*H5*), for which significantly less people than expected chose the “sad” response (0.0%). These results indicate that certain acoustic properties increase or decrease the likelihood that a person will perceive a knock as angry, sad, happy, etc. Notable examples are included in the table portraid in Figure1. For the full data set, see Appendix II.

			PerceivedEmo					
			Anger	Fear	Happiness	Sadness	Neutral	Total
KnockerEmo	A3	Count	24a	26a	22a	0b	26a	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	24,5%	26,5%	22,4%	0,0%	26,5%	100,0%
		% within PerceivedEmo	3,8%	6,7%	6,2%	0,0%	3,6%	4,0%
		Standardized Residual	−0,3	2,7	2,0	−3,7	−0,6	
	A4	Count	80a	11b	2b, c	2b, c	3c	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	81,6%	11,2%	2,0%	2,0%	3,1%	100,0%
		% within PerceivedEmo	12,5%	2,8%	0,6%	0,6%	0,4%	4,0%
		Standardized Residual	10,8	−1,1	−3,2	−3,1	−4,8	
	F2	Count	71a	8b	5b	1b	13b	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	72,4%	8,2%	5,1%	1,0%	13,3%	100,0%
		% within PerceivedEmo	11,1%	2,1%	1,4%	0,3%	1,8%	4,0%
		Standardized Residual	9,0	−1,9	−2,5	−3,4	−3,0	
	F3	Count	63a	17b	7b, c	2c	9c	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	64,3%	17,3%	7,1%	2,0%	9,2%	100,0%
		% within PerceivedEmo	9,9%	4,4%	2,0%	0,6%	1,2%	4,0%
		Standardized Residual	7,4	0,4	−1,9	−3,1	−3,7	
	F5	Count	79a	16b	2c	0c	1c	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	80,6%	16,3%	2,0%	0,0%	1,0%	100,0%
		% within PerceivedEmo	12,4%	4,1%	0,6%	0,0%	0,1%	4,0%
		Standardized Residual	10,6	0,1	−3,2	−3,7	−5,2	
	H2	Count	0a	4a, b	68c	5b	21b	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	0,0%	4,1%	69,4%	5,1%	21,4%	100,0%
		% within PerceivedEmo	0,0%	1,0%	19,0%	1,5%	2,9%	4,0%
		Standardized Residual	−5,1	−2,9	14,2	−2,3	−1,5	
	H3	Count	27a, b	17a, b	28b	1c	25a	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	27,6%	17,3%	28,6%	1,0%	25,5%	100,0%
		% within PerceivedEmo	4,2%	4,4%	7,8%	0,3%	3,4%	4,0%
		Standardized Residual	0,3	0,4	3,6	−3,4	−0,8	
	H4	Count	43a	15a	13a	1b	26a	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	43,9%	15,3%	13,3%	1,0%	26,5%	100,0%
		% within PerceivedEmo	6,7%	3,9%	3,6%	0,3%	3,6%	4,0%
		Standardized Residual	3,4	−0,1	−0,3	−3,4	−0,6	
	H5	Count	21a	13a	22a	0b	42a	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	21,4%	13,3%	22,4%	0,0%	42,9%	100,0%
		% within PerceivedEmo	3,3%	3,4%	6,2%	0,0%	5,8%	4,0%
		Standardized Residual	−0,9	−0,6	2,0	−3,7	2,4	
	S2	Count	3a	10b, c	2a, c	57d	26b	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	3,1%	10,2%	2,0%	58,2%	26,5%	100,0%
		% within PerceivedEmo	0,5%	2,6%	0,6%	16,9%	3,6%	4,0%
		Standardized Residual	−4,5	−1,4	−3,2	11,8	−0,6	
	S3	Count	1a	18b	12b	51c	16b	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	1,0%	18,4%	12,2%	52,0%	16,3%	100,0%
		% within PerceivedEmo	0,2%	4,7%	3,4%	15,1%	2,2%	4,0%
		Standardized Residual	−4,9	0,7	−0,6	10,2	−2,4	
	N5	Count	9a	2a	9a	6a	72b	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	9,2%	2,0%	9,2%	6,1%	73,5%	100,0%
		% within PerceivedEmo	1,4%	0,5%	2,5%	1,8%	9,9%	4,0%
		Standardized Residual	−3,3	−3,4	−1,4	−2,0	7,9	

Fig. 1. Notable examples from the crosstabulation of survey results.

B. Acoustic analysis

We decided to assess, for every sound feature, which emotion(s) can be particularly distinguished from the others, with a threshold for relevance that was arbitrarily decided for each case. The result is therefore approximate, but even broad estimations such as the following ones can be interpreted as significant for the main goal of our project, which is to find out whether knocking sounds can convey emotions at all – i.e. whether specific emotions can be distinguished by the listeners. We aim to compare the inferred hypothesis with the trends that emerge from the data gathered during the survey phase.
All the following sections refer to the corresponding graph in Figure 2 and Figure 3.

1) Number of knocks:

- Fear has a higher number of knocks compared to the other emotions (1.2 more than the closest value on average).
- Neutral and sadness together have a lower number of knocks compared to the other emotions (2.2 fewer than the closest value on average).
- Anger and happiness have the same number of knocks on average.

2) Duration:

- Fear sounds (from onset of the first knock of the sequence to onset of the last) are longer than the other emotions (0.264 seconds more than the closest value on average).

– Anger and sadness have very similar durations (0.045 seconds difference on average).

3) Knock frequency:

– Happiness sounds have a higher knocking frequency compared to the other (1.059029647 more knocks per second than the closest value on average).

– Neutral and sadness together have a lower knocking frequency compared to the other emotions (1.239015892 fewer knocks per second than the closest value on average).

– Anger and fear have very similar knock frequencies (0.07657468561 knocks per second difference on average).

4) Maximum RMS amplitude:

– Anger and fear together are louder compared to the other emotions (4.367 dB SF more than the closest value on average).

– Sadness is fainter compared to the other emotions (7.48 fewer dB SF than the closest value on average).

5) ITU-R BS.1770-3:

– Sadness is fainter compared to the other emotions (7.982 fewer LUFS than the closest value on average).

– Anger and fear have very similar loudness (1.498 LUFS difference on average).

6) Global frequency:

– Happiness sounds have higher frequencies compared to the other emotions (60.62 Hz of difference with the closest value on average).

– Fear sounds have lower frequencies compared to the other emotions (23.136 Hz of difference with the closest value on average).

7) Inter-Onset Interval variation:

– The results are highly variable because of some very regular knocking records, strongly increasing the value of the variance between the records, which means increasing the size of the 95% intervals.

– However, we can see that anger and fear have surprisingly low IOI variation compared to the others; meaning that, for those emotions, the knockers was regular.

– We don't have IOI variation for 2 of the records, because they contain only two knocking sounds; and we discarded another outlier, from a record made of 3 very distant knocking sounds, giving aberrant values.

C. Correlation between emotional content and properties

By exploring the properties of records that have been most reliably perceived as angry, we can make hypothesis

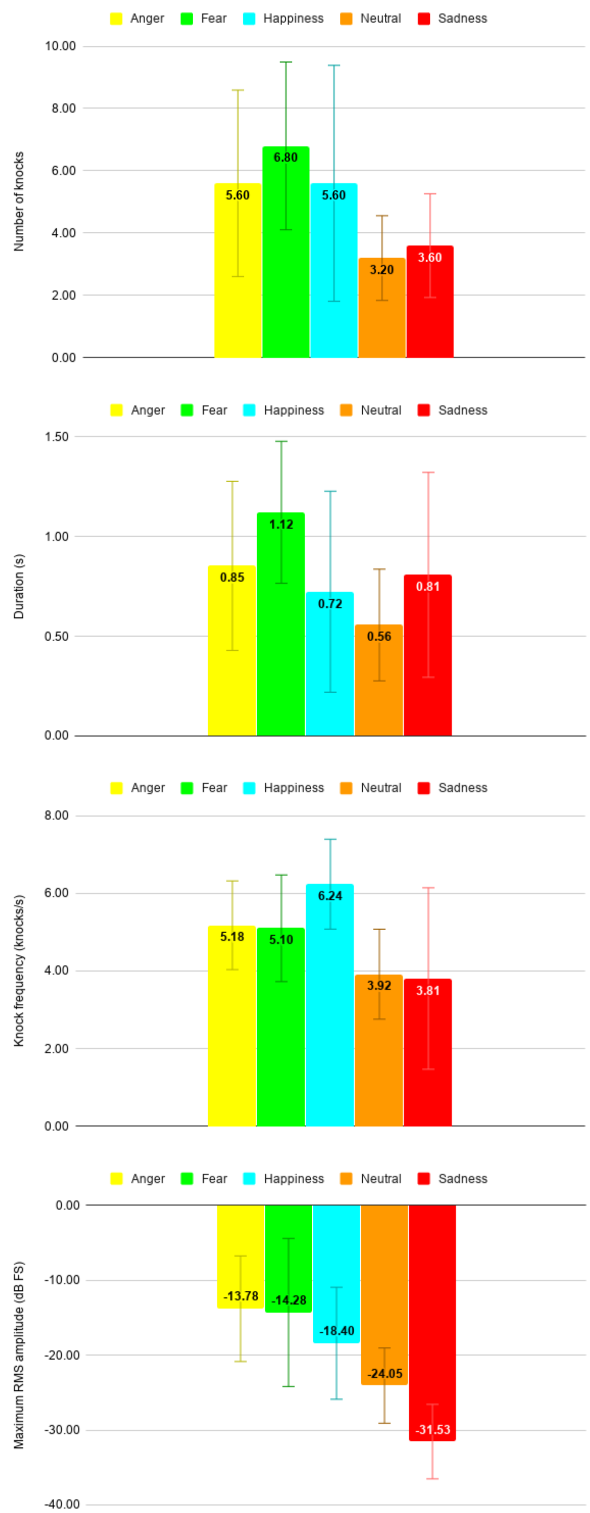

Fig. 2. Mapping different acoustic features across different emotions.

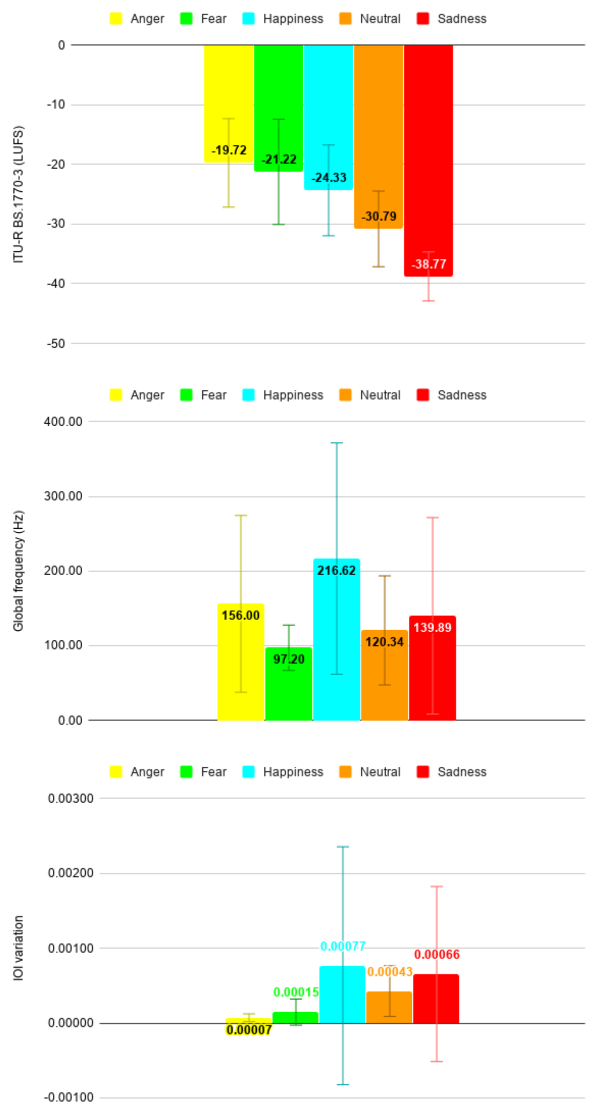

Fig. 3. Mapping different acoustic features across different emotions (continues).

on the characteristics carrying that information in the sound. The results are supported by the analysis of the same properties for records that have almost never been perceived as angry. When we consider records *A4*, *F2*, *F3* and *F5* (most reliably perceived as angry) we can observe particularly high Maximum RMS amplitude and particularly low IOI variation. Then, if we consider *S1*, *S2* and *S3* (almost never perceived as angry) it is the other way around. Those results are summarised in Table I.

We can repeat the processing of different set of records and process the records that have been perceived as sad or not. Then, we can consider S2 and S3 (most reliably perceived as sad) and A3, H3, H4 and H5 (almost never perceived as sad). We can see a clear difference between

TABLE I
RMS AMPLITUDE AND IOI VARIATION FOR PARTICULAR RECORDS

Dataset	Maximum RMS amplitude	IOI variation
Means over A4, F2, F3 and F5	-8,82 dB FS	6,50x10-5
Means over S1, S2 and S3	-30,73 dB FS	96,18x10-5
Overall means	-14.26 dB FS	40,94x10-5

the knock frequencies of the two sound groups. The differences are summarised in Table II.

TABLE II
KNOCKING FREQUENCY FOR PARTICULAR RECORDS

Dataset	Knock frequency
Means over S2 and S3	1,79 knocks/s
Means over A3, H3, H4 and H5	6,29 knocks/s
Overall means	4.06 knocks/s

Given the number of relevant records, we can not conclude upon the characteristics responsible for the emotion perception of knocking sounds. But, we can now make strong hypothesis:

- The perception of anger seems to be correlated with the loudness of the sound, and the regularity of knocks.
- The perception of sadness seems to be correlated with a low knock frequency.

V. Discussion

It was noted from the perception test that neutral was the most chosen answer in the survey. However, only one neutral knocking sequence increased the proportion of neutral responses. This might be because most respondents considered neutral as their go-to option when they were uncertain about the answer.

Responses to knocking sequences corresponding to fear were notably inconsistent. One of the recordings seemed to cause respondents to choose happy while several others made the respondents pick anger. This might be caused by the different ways in which it is possible to interpret fear. A respondent may picture a scenario where the knocker is anxious and knocks softly, or a scenario where the knocker is panicked and knocks louder. A better term for this emotion could be panic which is better associated with our scenario.

An important influence in the performance of the knocking activity during the recording session might have been brought by each participant's own culture and background. As previously mentioned, the six people involved came from five different countries, which are sometimes characterised by deeply different histories and habits, hence the way those people knock might have been affected by such a geographical imprint. As a matter of fact, not only knocking “styles” (e.g. open palm, closed fist, side fist) sometimes changed from one emotion to the other, but also within the same emotion recordings the approach was never the same for everybody. This reasoning can be applied to the potential listeners of the knocking sounds: perceiving and interpreting everyday stimuli in everyday situations might vary depending on culture, a theory that would explain (at least partially) the variation of the responses received in the perception test.

The reason why we chose to carry on the test as an online survey rather than a controlled-environment laboratory experiment was because it was our intention of reaching more people that we could possibly involve given our time and resource constraints; supporting our choice was the fact that people are used to hearing knocking sounds when they are distracted and are doing something else, so distraction in listeners during the test would not be as disruptive after all. Plus, as previously mentioned, the survey was designed to last a fairly short amount of time (overall, it took about 5 to 10 minutes to complete), with the specific aim of reducing the risk of distractions or drop-outs.

The present study was carried out part-time over the course of a month and was consequently associated with a number of limiting factors which could be improved upon. Firstly, recordings and perceptual tests could be made with better material and in better controlled settings. Access to a Foley artist or an anechoic chamber could for instance increase the quality of recordings. Secondly, the response-alternatives could be better aligned with the intended emotion, e.g. panic instead of fear, to increase the likelihood of finding significant effects. The scope of the study can be expanded to include more emotions or a larger set of recording for each emotion, as well as different door- and room-types. Related to this, it might be interesting to record knocks from the opposite side of the door, i.e. from the perceiver’s perspective. Further analyses and tests could be made to correlate specific acoustic properties with perception of emotion. Such properties could then used to predict emotional judgements, or alternatively be altered synthetically in order to affect respondents’ emotional judgements.

Acknowledgment

We would like to thank our supervisor Mrs. Sandra Pauletto, for her support, advice and help. She always showed a lot of interest in our work and kept us motivated.
We are also grateful to Mr. Adrián Barahona Ríos for the support, to Mr. Roberto Bresin for the material of his work, and to KTH for giving us access to the places and equipment we needed for the recording session.

References

[1] R. Vitale and R. Bresin, “Emotional cues in knocking sounds,” unpublished.
[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
[3] X. Li, R. J. Logan and R. E. Pastore, “Perception of acoustic source characteristics: Walking sounds,” in The Journal of the Acoustical Society of America, vol. 90(6), pp. 3036–3049, December 1991.
[4] S. Mcadams, V. Roussarie and A. Chaigne, “The psychomechanics of simulated sound sources: Material properties of impacted bars,” in The Journal of the Acoustical Society of America, vol. 115(3), pp. 1306–1320, April 2004.
[5] A. Barahona and S. Pauletto, “Perceptual Evaluation of Modal Synthesis for Impact-Based Sounds,” in Conference: Sound and Music Computing Conference at Màlaga, Spain, May 2019.
[6] R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.
[7] B. L. Giordano and S. Mcadams, “Sound Source Mechanics and Musical Timbre Perception: Evidence From Previous Studies,” in Music Perception, vol. 28(2), pp. 155–168, December 2010.
[8] E. Lindström, P. N. Juslin, R. Bresin and A. Williamon, “‘Expressivity comes from within your soul’: A questionnaire study of music students’ perspectives on expressivity,” in Research Studies in Music Education, vol. 20, pp. 23–47, 2003.
[9] https://www.sogosurvey.com, visited on October 17, 2019.

Appendix I

Fig. 4. Setup of the recording equipment.

Appendix II

KnockerEmo * PerceivedEmo Crosstabulation

			PerceivedEmo					
			Anger	Fear	Happiness	Sadness	Neutral	Total
KnockerEmo	A1	Count	64a	31a	1b	1b	1b	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	65,3%	31,6%	1,0%	1,0%	1,0%	100,0%
		% within PerceivedEmo	10,0%	8,0%	0,3%	0,3%	0,1%	4,0%
		Standardized Residual	7,6	4,0	−3,5	−3,4	−5,2	
	A2	Count	16a	3a	4a	13a, b	62b	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	16,3%	3,1%	4,1%	13,3%	63,3%	100,0%
		% within PerceivedEmo	2,5%	0,8%	1,1%	3,8%	8,5%	4,0%
		Standardized Residual	−1,9	−3,2	−2,7	−0,1	6,1	
	A3	Count	24a	26a	22a	0b	26a	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	24,5%	26,5%	22,4%	0,0%	26,5%	100,0%
		% within PerceivedEmo	3,8%	6,7%	6,2%	0,0%	3,6%	4,0%
		Standardized Residual	−0,3	2,7	2,0	−3,7	−0,6	
	A4	Count	80a	11b	2b, c	2b, c	3c	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	81,6%	11,2%	2,0%	2,0%	3,1%	100,0%
		% within PerceivedEmo	12,5%	2,8%	0,6%	0,6%	0,4%	4,0%
		Standardized Residual	10,8	−1,1	−3,2	−3,1	−4,8	
	A5	Count	47a	7b, c	6b, c	2c	36a, b	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	48,0%	7,1%	6,1%	2,0%	36,7%	100,0%
		% within PerceivedEmo	7,4%	1,8%	1,7%	0,6%	4,9%	4,0%
		Standardized Residual	4,2	−2,1	−2,2	−3,1	1,3	
	F1	Count	7a	38b	39b	1a	13a	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	7,1%	38,8%	39,8%	1,0%	13,3%	100,0%
		% within PerceivedEmo	1,1%	9,8%	10,9%	0,3%	1,8%	4,0%
		Standardized Residual	−3,7	5,7	6,5	−3,4	−3,0	
	F2	Count	71a	8b	5b	1b	13b	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	72,4%	8,2%	5,1%	1,0%	13,3%	100,0%
		% within PerceivedEmo	11,1%	2,1%	1,4%	0,3%	1,8%	4,0%
		Standardized Residual	9,0	−1,9	−2,5	−3,4	−3,0	
	F3	Count	63a	17b	7b, c	2c	9c	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	64,3%	17,3%	7,1%	2,0%	9,2%	100,0%
		% within PerceivedEmo	9,9%	4,4%	2,0%	0,6%	1,2%	4,0%
		Standardized Residual	7,4	0,4	−1,9	−3,1	−3,7	
	F4	Count	20a	35b	17a, b	1c	25a	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	20,4%	35,7%	17,3%	1,0%	25,5%	100,0%
		% within PerceivedEmo	3,1%	9,1%	4,8%	0,3%	3,4%	4,0%
		Standardized Residual	−1,1	5,0	0,7	−3,4	−0,8	
	F5	Count	79a	16b	2c	0c	1c	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	80,6%	16,3%	2,0%	0,0%	1,0%	100,0%
		% within PerceivedEmo	12,4%	4,1%	0,6%	0,0%	0,1%	4,0%
		Standardized Residual	10,6	0,1	−3,2	−3,7	−5,2	
	H1	Count	9a	41b	41b	0a	7a	98
		Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
		% within KnockerEmo	9,2%	41,8%	41,8%	0,0%	7,1%	100,0%
		% within PerceivedEmo	1,4%	10,6%	11,5%	0,0%	1,0%	4,0%
		Standardized Residual	−3,3	6,5	7,1	−3,7	−4,1	

Fig. 5. Crosstabulation of survey results.

H2	Count	0a	4a, b	68c	5b	21b	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	0,0%	4,1%	69,4%	5,1%	21,4%	100,0%
	% within PerceivedEmo	0,0%	1,0%	19,0%	1,5%	2,9%	4,0%
	Standardized Residual	−5,1	−2,9	14,2	−2,3	−1,5	
H3	Count	27a, b	17a, b	28b	1c	25a	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	27,6%	17,3%	28,6%	1,0%	25,5%	100,0%
	% within PerceivedEmo	4,2%	4,4%	7,8%	0,3%	3,4%	4,0%
	Standardized Residual	0,3	0,4	3,6	−3,4	−0,8	
H4	Count	43a	15a	13a	1b	26a	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	43,9%	15,3%	13,3%	1,0%	26,5%	100,0%
	% within PerceivedEmo	6,7%	3,9%	3,6%	0,3%	3,6%	4,0%
	Standardized Residual	3,4	−0,1	−0,3	−3,4	−0,6	
H5	Count	21a	13a	22a	0b	42a	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	21,4%	13,3%	22,4%	0,0%	42,9%	100,0%
	% within PerceivedEmo	3,3%	3,4%	6,2%	0,0%	5,8%	4,0%
	Standardized Residual	−0,9	−0,6	2,0	−3,7	2,4	
S1	Count	1a	17b	17b	18b	45b	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	1,0%	17,3%	17,3%	18,4%	45,9%	100,0%
	% within PerceivedEmo	0,2%	4,4%	4,8%	5,3%	6,2%	4,0%
	Standardized Residual	−4,9	0,4	0,7	1,2	2,9	
S2	Count	3a	10b, c	2a, c	57d	26b	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	3,1%	10,2%	2,0%	58,2%	26,5%	100,0%
	% within PerceivedEmo	0,5%	2,6%	0,6%	16,9%	3,6%	4,0%
	Standardized Residual	−4,5	−1,4	−3,2	11,8	−0,6	
S3	Count	1a	18b	12b	51c	16b	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	1,0%	18,4%	12,2%	52,0%	16,3%	100,0%
	% within PerceivedEmo	0,2%	4,7%	3,4%	15,1%	2,2%	4,0%
	Standardized Residual	−4,9	0,7	−0,6	10,2	−2,4	
S4	Count	2a	15b, c	3a, c	48d	30b	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	2,0%	15,3%	3,1%	49,0%	30,6%	100,0%
	% within PerceivedEmo	0,3%	3,9%	0,8%	14,2%	4,1%	4,0%
	Standardized Residual	−4,7	−0,1	−3,0	9,4	0,1	
S5	Count	1a	7b	5a, b	22c	63c	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	1,0%	7,1%	5,1%	22,4%	64,3%	100,0%
	% within PerceivedEmo	0,2%	1,8%	1,4%	6,5%	8,6%	4,0%
	Standardized Residual	−4,9	−2,1	−2,5	2,3	6,3	
N1	Count	0a	7b	9b, c	39d	43c	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	0,0%	7,1%	9,2%	39,8%	43,9%	100,0%
	% within PerceivedEmo	0,0%	1,8%	2,5%	11,5%	5,9%	4,0%
	Standardized Residual	−5,1	−2,1	−1,4	6,9	2,6	
N2	Count	2a	3a, b	13b, c	23c	57c	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	2,0%	3,1%	13,3%	23,5%	58,2%	100,0%
	% within PerceivedEmo	0,3%	0,8%	3,6%	6,8%	7,8%	4,0%
	Standardized Residual	−4,7	−3,2	−0,3	2,6	5,1	
N3	Count	1a	7b	2a, b	39c	49c	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	1,0%	7,1%	2,0%	39,8%	50,0%	100,0%
	% within PerceivedEmo	0,2%	1,8%	0,6%	11,5%	6,7%	4,0%
	Standardized Residual	−4,9	−2,1	−3,2	6,9	3,7	
N4	Count	48a	18a, b	8b	5b	19b	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	49,0%	18,4%	8,2%	5,1%	19,4%	100,0%
	% within PerceivedEmo	7,5%	4,7%	2,2%	1,5%	2,6%	4,0%
	Standardized Residual	4,4	0,7	−1,7	−2,3	−1,9	
N5	Count	9a	2a	9a	6a	72b	98
	Expected Count	25,6	15,4	14,3	13,5	29,2	98,0
	% within KnockerEmo	9,2%	2,0%	9,2%	6,1%	73,5%	100,0%
	% within PerceivedEmo	1,4%	0,5%	2,5%	1,8%	9,9%	4,0%
	Standardized Residual	−3,3	−3,4	−1,4	−2,0	7,9	
Total	Count	639	386	357	338	730	2450
	Expected Count	639,0	386,0	357,0	338,0	730,0	2450,0
	% within KnockerEmo	26,1%	15,8%	14,6%	13,8%	29,8%	100,0%
	% within PerceivedEmo	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Each subscript letter denotes a subset of PerceivedEmo categories whose column proportions do not differ significantly from each other at the .05 level.

Fig. 6. Crosstabulation of survey results (continues).