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KNOCKING ON A YELLOW DOOR: INTERACTIONS AMONG KNOCKING SOUNDS, COLOURS, AND EMOTIONS.

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ABSTRACT

Studies on the ability of music to elicit emotions in listeners have a long tradition. Less studied are the relationships between emotions and everyday sounds, such as environmental noises or sounds of human actions. Exceptions are some experiments that have shown walking sounds, in a manner similar to characteristics of music, can be related to emotions. Furthermore, everyday sounds play a particular role in some media, such as video games and movies, where they are associated with visual contents. In this context, we present a study (n=60) to investigate the hypothesis that the association between knocking sounds and emotions change according to the colour of the door. We used videos instead of still images of a hand knocking on doors with different colours. Results show no statistically significant effect of colours on the perception of emotions associated to the knocking sounds. Anyway, some interesting trends can be recognized, e.g., knocking sounds were perceived as happier if the hand knocks on a yellow door.

Keywords: *crossmodal interaction, sound design, everyday sounds, emotions.*

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1. INTRODUCTION

Everyday sounds are very important means of information: from the identification of the source of an event, e.g. a car crash, to the recognition of specific emotional states, e.g. an angry person knocking on our door. The combination and recognition of different sound parameters, such as intensity, pitch, timbre, duration and regularity, are of fundamental importance both when designing the sound for an artefact and for a media product, as well as in everyday life. It has been shown that combinations of sound parameters in walking[6][7] or knocking[4] sounds can systematically be associated with or induce emotional states in a listeners.
However, when these types of sounds are placed in a multimedia context, such as a movie or an advertisement, the possible interaction between the aural and visual components should be considered. In fact, it has been shown that visual aspects and particularly colours can also be related to emotions[10]. When colours are congruent with emotion (e.g., a colour associated with a positive emotion, and the presence of a 'positively valenced' sound), we would expect the emotion perceived to be commensurate with those of the component sensory experiences (positive emotion perceived). However, it is not as clear what emotion would be detected if two synchronised sensory stimuli produce conflicting emotions. What if sounds associated with positive emotions (e.g., happiness) are presented together with colours normally associated with negative emotions (e.g., sadness)? Is there a prevailing mode? If so, which one? Are cross-modal interaction phenomena[8] observable and if so, of what intensity?

This paper investigates the results of an experiment aimed at investigating the influence of certain colours, proved to be associated with specific emotions, on emotionally performed knocking sounds. We hypothesise that the association between knocking sounds and emotions changes if the knocking sound is performed on a door of a different colour.

Knocking sounds are everyday impact sounds that have the power to elicit emotions in the listener, as previously investigated [1][2][3][4]. The starting point for our work is the experiment conducted by Sandra Pauletto and Alessandro Iop[5] in which they investigated the perception of emotions in multimodal stimuli, namely emotional knocking actions presented together with images of doors of different colours and materials. Their results showed a prevalence of the aural modality on the visual one. However, this result may be due to some methodological limitations. In particular, the visual part of each stimulus was a static picture of a door, which might have conditioned subjects to pay more attention to the time-evolving aural part, i.e. a rhythmic knocking sound, since more dynamic information was present in the auditory component of the stimulus. The main difference in our experiment, therefore, is to use more realistic stimuli, in which the visual part is a movie of a hand knocking on a door. Moreover, the literature on the emotion-colour relations often put emphasis on the importance of dimensions such as luminance and saturation; different nuances of red or yellow may be more or less associated with emotions, depending for example on their brightness level. Therefore, unlike Pauletto and Iop[5], we selected a specific colour palette, detailed in terms of RGB values.

2. EXPERIMENT

2.1 Materials

For this experiment, audio stimuli were selected from Barahona-Ríos and Pauletto's dataset[1] of emotional knocking actions[1], which has also been used in Pauletto and Iop[5]. These knocking actions were performed by Ulf Olausson, a professional Foley artist. This dataset was chosen due to this prior validation and also because it is professionally performed; together this suggests that the quality of the sound and overall performance should be better for examination than knocking actions performed by non-trained volunteers. Five audio recordings were chosen, with each representing one emotion listed in the procedure subsection, as well as a neutral example. To construct the visual stimuli, videos of a hand knocking on a white door were recorded. First, each audio recording was listened to multiple times to render the synchronisation between the knocking action and the sound in the best way possible. The videos were recorded using an iPhone 8 external camera, and edited using HitFilm Express to add the audio and trim the length of each video to 3 seconds. Finally, Adobe Premiere Pro was used to change the colour of the door.

After a detailed analysis of the existing literature[11-21], the following colours were chosen, because they have been shown to be generally associated with certain basic emotions:

- Yellow (hex code: #ede939) [12, 13]
- Red (hex code: #d7414b) [13]
- Purple (hex code: #a36ab8) [14]
- Grey (hex code: #838686) [12]
- White (hex code: #e6dfdc) (natural door colour)

Although the literature shows some variance in the association between colours and emotions, the first four colour shades tend to be associated with happiness, angry, fear, and sad, respectively. The white case has been added as a baseline. In total, twenty-five audio-visual stimuli were produced[2], by combining each of the five audio stimuli with each of the five colours.

2.2 Procedure

An online questionnaire was created using the platform PsyToolkit[3] (Stoet, 2010, 2017). After a brief presentation of the study aims and privacy policy, participants were informed of the structure of the survey. Twenty-five questions were presented, each comprised of a 3 second video followed by four sliders. The videos and sliders were positioned on the same page. After watching the video, which could be seen as many times as they preferred, participants rated how much the current stimulus was associated with a basic emotion, by moving the four sliders constructed on a continuous scale ranging from 0 (total disagreement) to 10 (maximum agreement). Before each slider, the following statements were presented:

- The emotion expressed in the video is HAPPINESS
- The emotion expressed in the video is SADNESS
- The emotion expressed in the video is FEAR
- The emotion expressed in the video is ANGER.

[1] https://zenodo.org/record/3668503#.YqcHbqhBy5c

[2] https://zenodo.org/record/7932448#.ZGFI4C9BxQJ

[3] https://www.psytoolkit.org/

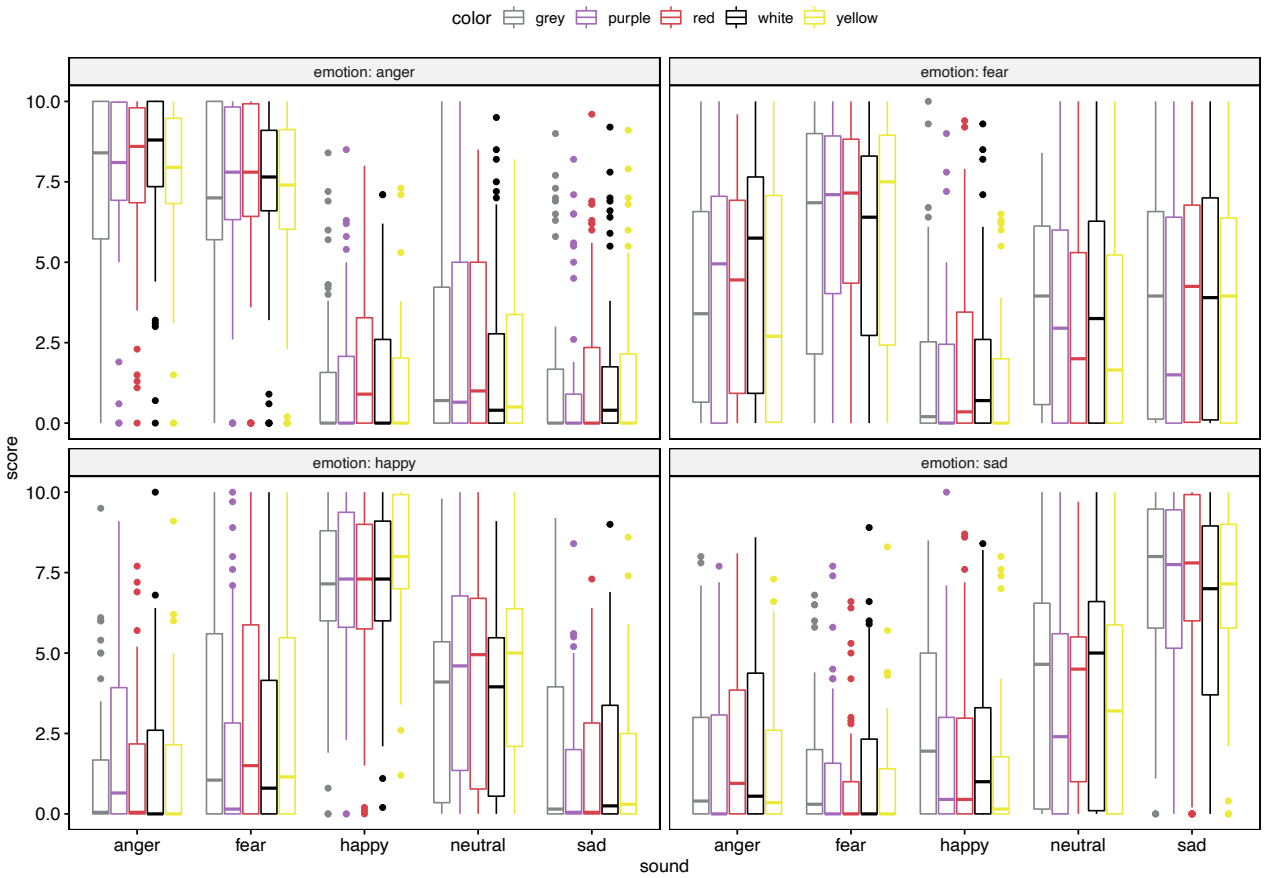

Figure 1. Boxplots of the subjects' judgement on a scale from 0 to 10. Participants were asked subjects to rate each stimulus using four sliders, each associated with an emotion. Each frame in this figure reports the scores on one of these emotions (from top-row: anger, fear; bottom-row: happy, sad). The labels along the x-axis (anger, fear, happy, neutral, sad) refer to the expressive intentions of the knocking sounds. The colour of the bars, as reported in the legend, is that of the door in the visual component of the stimuli.

Stimulus ordering was randomised for each participant. Before starting the experiment, participants listened to two audio recordings, one high in intensity and the other one low, in order to adjust the audio levels of their device speakers or headphones. Participants were instructed not to change audio levels throughout the course of the experiment. These two audio samples were randomly extracted from the same main dataset used for the experiment. Different audio stimuli were used for volume adjustment from the main study in order to avoid bias responses. At the end of the twenty-five stimuli ratings, some personal data were collected (gender, age, country of origin) as well as information about the participants' sight and hearing state. Furthermore, since the experiment involves the union of two senses, they were presented with a set of questions investigating synaesthesia, taken from McDonald et al.[9].

2.3 Participants

Sixty-six participants completed the questionnaire. However, six participants were removed from the dataset prior to analysis. This was due to reports of hearing (1) and sight (1) disorders, such as colour blindness—an essential factor for the success of the experiment—or reporting not watching all the videos (3), or reporting not paying attention to the visual component of the stimuli (1). Therefore, data

from a total of 60 participants were retained for further analysis. 33 participants were female (55%), 25 male (41%), 1 non-binary (2%) and 1 preferred not specify their gender (2%). Age ranged 18-66 years, with 32 people in the 18-25 range (54%), 17 in the 26-34 (29%), 4 in the 35-42 (7%), 2 in the 43-50 (3%), 3 in the 51-59 (5%) and 1 above 60 years old (2%). Most participants (85%) resided in Italy (51), with other countries of residence being the United States of America (2), Turkey (2), Brazil (1), Finland (1), Iran (1), Morocco (1), and Russia (1).

3. RESULTS

Figure 1 reports the boxplots of the participant ratings. The frames in the figure represent the four sliders used to rate each of the 25 stimuli. The labels along the x-axis (anger, fear, happy, neutral, sad) refer to the expressive intentions of the knocking sounds, as validated by Pauletto and Iop[5], and the colour of the boxes corresponds to the colour of the door in the visual part of the stimuli. A three-way ANOVA was used to determine how the different factors affect the ratings. Results in Table 1 show that none of the interactions between the three factors are statistically significant ($p > .05$), except for the two-way interaction between the expressive intention of the knocking sounds and the perceived emotions (sound:emotion). This suggests that the association between the multimedia stimuli and the emotion is primarily influenced by the auditory mode than the visual one.

Table 1. Results of the ANOVA.

Effect	DFn	DFd	F	Sig.	p<.05
sound	2.96	168.77	23.306	$p < .001$	*
colour	4.00	228.00	2.747	$p = .029$	*
emotion	3.00	171.00	7.969	$p < .001$	*
sound:colour	16.00	912.00	1.407	$p = .13$	
sound:emotion	6.19	352.84	121.845	$p < .001$	*
colour:emotion	8.94	509.47	1.733	$p = .079$	
sound:colour:emotion	21.62	1232.45	1.219	$p = .222$	

Stimuli intended to represent happy, sad and anger knocking sounds were consistently rated high in these emotions (see Figure 1). In contrast, stimuli with fear knocking sounds received high scores on both the anger and fear slider, implying that it is difficult to communicate fear alone through knocking sounds.

Regarding the effect of colours on participant ratings of the four basic emotions, this did not produce statistically significant results, and contained relatively high variance in the responses. However, some trends can be observed in the data in Figure 1. Yellow colour was associated with an increase in perceived happiness when it was combined with a happy sound or a neutral sound. On the other hand, red colour seemed to induce perception of happy and neutral knocking sounds as more angry. Neutral sounds were also rated higher in fear when appearing with a purple door. Finally, a grey door was associated with increased sadness rating of sad knocking sounds; indeed even happy sounds are perceived as sadder when associated with a grey.

4. CONCLUSIONS

An experiment was performed to investigate the hypothesis that the association between knocking sounds and emotion changes if the knocking sound is performed on a door of a different colour. In line with Pauletto and Iop[5], results show no statistically significant effect of colours on the perception of emotions associated to the knocking sounds. Independently from the visual modality, knocking sounds representing the emotions happy, sad and anger are the most likely to be identified correctly. On average, the neutral audio stimuli were also correctly identified, since participants gave medium to lower scores to these videos, meaning that they did not identify a specific emotion among the ones presented. On the other hand, fear tended to be confused with anger.

Looking at the scores obtained from the same knocking sound as the colour of the door changes, some trends can be identified, especially concerning happiness and sadness with yellow and grey, respectively, although these differences are not statistically significant.

In conclusion, our experiment confirms the findings of Pauletto and Iop[5] and McDonald et al.[9], supporting a predominance of the aural modality on the visual one in this kind of task.

Some limitations may have influenced this result, so we believe the effect of colours deserves further investigation. In our case, the difficulty in distinguishing stimuli representing fear from those representing anger may have contributed to increased variance in the data. Therefore, we recommend further study with fewer variables/emotions. Such an approach may provide more detailed and reproducible findings on the effect of colours for perceptions of knocking sounds. Moreover, an increase in the number of participants might facilitate the emergence of additional statistically significant associations.

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