PERCEPTION OF EMOTIONS IN MULTIMODAL STIMULI: THE CASE OF KNOCKING ON A DOOR

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ABSTRACT

Knocking sounds are highly expressive. In our previous research we have shown that from the sound of knocking actions alone a person can differentiate between different basic emotional states. In media productions, such as film and games, knocks can be very important storytelling devices as they allow the story to transition from one part to another. Research has shown that colours can affect our perception of emotions. However the relationship between colours and emotions is complex and dependent on multiple factors. In this study we investigate how the visual characteristics of a door, more specifically its colour, texture and material, presented together with emotionally expressive knocking actions, can affect the perception of the overall emotion evoked in the audience. Results show that the door´s visual characteristics have little effect on the overall perception of emotions, which remains dominated by the emotions expressed by the knocking sounds.

1. INTRODUCTION

Knocking on a door is a very common everyday sound. Much information can be conveyed through such a simple yet expressive action: from perceiving the way the knock is performed (e.g. closed or open palm), to recognising the emotional intention of the person knocking on the door. Understanding how communication through everyday sounds takes place, and in particular how emotions can be recognised through these sounds, is of fundamental importance when designing and synthesising everyday sounds with a specific intention to be conveyed. Media industries such as gaming, advertising and cinema can benefit from technologies informed by knowledge of cross-modal perception in order to produce the desired effects on their audiences. Research on how emotional intentions are expressed in everyday sounds is relatively recent, especially in comparison to what we know about emotions and music or voice. A number of studies in recent years have expanded on the knowledge of human perception of emotions in aural stimuli of different nature [1–4]. Within this broader field of research, there is little exploration of the effect of knocking sounds on the emotions perceived by a listener. The aim of the present study is to build upon

previous research on everyday sounds and emotions by focusing on audiovisual integration in multimodal stimuli of knocking sounds. More specifically, we assess the effect that audiovisual integration has on the perception of five basic emotional states (anger, fear, happiness, sadness and neutral). We investigate how audio and visual modalities, carrying congruent as well as non-congruent emotional information, interact in a simple representation of a knocking action performed on a door, and contribute to producing the perception of an overall emotion. In this regard, Gerdes et al. [5] explored how audio and visual cues interact to steer attention. The study shows that emotional auditory cues guide visual spatial allocation of attention specifically to emotionally congruent pictures.

We conducted a pre-study and an audiovisual experiment. The pre-study involved visual-only stimuli of doors of different colours, materials and textures. The aim of this study was to use its results, in conjunction with findings from literature on colour and emotions, to select 5 different coloured doors associated with anger, fear, happiness, sadness and neutral. In the subsequent audiovisual experiment, we combined 5 knocking action sounds, which in our previous study [6] were rated to be strongly associated with the same 5 basic emotions, with the 5 coloured doors. In this experiment, we aimed to investigate whether the combination of the appearance of the door with an emotional knocking sound could affect the overall emotional perception [1].

The next sections are organised as follows: in Background (§2) the most relevant previous research and theoretical background is reviewed; in Method (§3) the description of the experimental design is presented; in Results (§4) a summary of the statistical analysis of the collected data is reported; in Discussion (§5) results are discussed in light of previous research, and in Conclusions (§6) the work is summarised and directions for further work are outlined.

2. BACKGROUND

Everyday sounds can communicate complex information [7]. Furthermore, even sounds without explicit connection with everyday objects or actions, such as tones and noise complexes, can produce an emotional reaction [8]. Furthermore, emotions, as well as other characteristics such as material and shape of an object [3, 9, 10], are an integral part of auditory perception and are used to categorise ev-

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[1] see stimuli from pre-study and audiovisual experiment here: https://kth.box.com/s/ske2j9gzzl7eclnzehlrlfzqt7hy3acq

eryday sounds [4]. From someone´s footstep, for example, we can infer many characteristics of the walker including gender, type of sole, and emotional intentions [2]. In regard to knocking sounds, our recent research has shown that basic emotional intentions such as anger, fear, happiness, sadness, and neutral state can be recognised from listening to knocking sounds alone [11]. Additionally, when utilising a large dataset of knocking action sounds produced by a professional Foley artist the degree of emotion recognition increases, showing only confusion between the labelling of anger and fear [6]. We also showed that emotion-specific acoustic patterns in knocking sounds confirm findings from previous research in speech and music performance [2, 12]

In this study, we selected 5 knocking sound actions from our data-set [2] of professionally performed knocking actions that were most strongly associated with anger, fear, happiness, sadness, and neutral state. We then combined them with visual representations of doors, which were created using Blender [3]. The design of these images was informed by research on colour, material and texture (i.e. the roughness and pattern of the surface). Research shows that colours can affect our emotional perception [13–15]. What emerges is a general agreement between most authors on a few colours (e.g. blue, red and yellow), although there is little consistency in the framework adopted for defining and categorising the colours and the emotions associated to them. Additionally, research shows that associations between colours and emotions depend on cultural factors [16, 17] as well as other aspects such as age [18–21]. Despite this complex picture, practical knowledge about colours is applied in many areas such as media production [22], marketing [23] or interior design [24]. Research on the association between materials and emotions, or textures and emotions appears to be limited. Crippa et al. [25] found that different materials can evoke emotions, even if weakly, such as satisfaction, joy, fascination, dissatisfaction and boredom. In relation to texture and emotion, Ebe and Umemuro [26] and Iosifyan and Korolkova [27] have found that people significantly associate basic emotions to different textures perceived through touch. For this study, we created 32 doors with different colours, materials and textures. Then, by combining the results of our the prestudy with findings from research on colour and emotion, we selected 5 doors that are strongly associated with the 5 basic emotions explored in this work.

3. METHOD

3.1 Pre-study

3.1.1 Stimuli

Thirty two images of closed doors (600 × 600 px), combining 8 colours (yellow, blue, black, grey, green, white, red, brown) and 4 materials plus textures (metal, smooth wood, intermediate wood, rough wood), were rendered using Blender 2.90.0 in a neutral indoor environment comprised of an off-white surrounding wall, a light grey floor

and basic door features (door frame of the same material of the door and a simple metallic-grey handle (e.g. Figure 1)). Six out of eight colours were chosen from the most frequently studied in previous colour and emotion research, while grey and brown were chosen as being the colours most commonly associated to a door of the selected materials.

Figure 1. Example of a door image used in the pre-study and the audiovisual experiment, depicting a red door with an intermediate wood texture.

3.1.2 Procedure

An online survey was created using the online platform PsyToolkit [4]. Participants were presented with the 32 images of doors. For each image, participants were asked to choose which emotional state the door evoked. The order of the stimuli and the options available for each question were randomised. Finally, for each door, participants were asked to select the colour and material/texture of the door by answering two separate single-choice questions. This allowed researchers, who did not have control over the viewing monitor, to confirm that participants viewed the visual characteristics of the doors correctly.

3.1.3 Participants

Twenty four participants participated in the survey. Six did not complete the survey and their results were therefore excluded. The remaining 18 participants (11 female, 7 male) were aged 19-65 (11 between 19 and 25; 5 between 26 and 35; 1 between 36 and 50; 1 above 50). None of the participants were colourblind.

3.2 Audiovisual experiment

3.2.1 Stimuli

In this experiment we used 30 audiovisual stimuli. These combined the 6 most strongly emotionally expressive knocking action sounds from our dataset recorded by a

professional Foley artist, one per each of the 5 basic emotions considered plus one additional neutral knocking action, and 5 images of doors associated with the same basic emotions selected from the pre-study stimuli. The reason for having two neutral knocking sounds was to be able to investigate in more detail whether the lack of a strongly recognisable emotion in the sound (neutral state) would allow for the emotion evoked by the visuals to affect the overall emotional perception more strongly. Finally, in order to select the 5 doors we combined the results from the pre-study (see §4) with findings from the literature in colour and emotions. Here the main selection criteria:

1. the door must be among those significantly associated, in the pre-study, with the emotion in question;

2. the door must have a relatively high absolute number of responses in the pre-study for the emotion considered;

3. associations between door characteristics and emotion must be confirmed, wherever possible, by previous research. [13, 16, 28] specifically support the red-anger pair, [20, 28] explicitly support the blue-happiness pair, [14, 29] associate yellow to negative valence/unpleasant feelings, and [14, 21] associate grey to negative valence and low arousal.

The doors selected were: anger = red + intermediate wood (RIW); fear = yellow + rough wood (YRW); happiness = blue + metal (BM); neutral = grey + smooth wood (GSW); sadness = brown + metal (BrwM).

3.2.2 Procedure

An online survey was created in PsyToolkit. Participants who had participated in the pre-study, or were knowledgeable about colour or sound theory were excluded. Before starting the test, participants were asked to adjust the volume in their headphones in order to be able to comfortably perceive both the softest and the loudest sounds used in the experiment. For each stimulus, the evoked emotional state was tested as a single-choice question. The order of the stimuli and the options available for each question were randomised.

3.2.3 Participants

One hundred and seven participants participated in the experiment. Among these, 52 did not complete the survey or had participated to our previous pre-study, and 20 had knowledge about colour or sound theory, and were therefore excluded from the analysis. Of the remaining 35 (15 female, 20 male) none were colourblind and their ages ranged as follows: 3 between 18 or below, 10 between 19 and 25, 5 between 26 and 35, 3 between 36 and 50, 14 between 51 and 65.

4. RESULTS

4.1 Pre-study

The Chi-Square test shows that there is a significant relationship between the doors´ colour and the perceived emo-

tions $\chi^2(28, N = 576) = 110.313, p < .01$. When considering the z-test pair-wise comparisons with a Bonferroni correction, we find that each emotion is significantly associated with a number of colours.
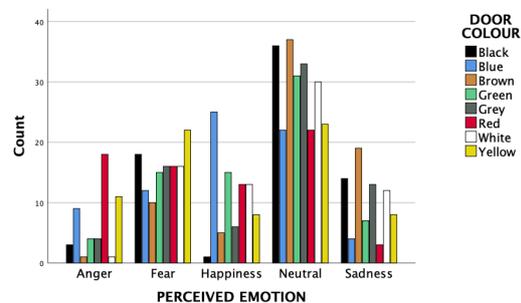

Figure 2. Pre-study: Door's colour vs perceived emotion.

Anger is significantly associated with red, yellow, blue. Red rough wood and red intermediate wood have the highest number of responses. Happiness is significantly associated with blue, green, red, white. Blue metal and blue intermediate wood have the highest number of responses. Sadness is significantly associated with brown, black, grey, green, white, yellow. Brown metal has the highest number of responses for sadness. In regard to fear, there is no significant difference in association with any of the colours. Yellow rough wood has the highest number of responses for fear. Similarly, for neutral state, there is no significant difference in association with any of the colours. Grey Smooth wood has the highest number of responses for neutral. When focusing on emotions and material/texture we find that fear is significantly associated with rough wood, while happiness and neutral are not associated with rough wood. Finally, the colours were correctly recognised (94.4% of the time, on average), with the sole exception of the metal white door, which was confused with the metal grey door 38.8% of the time. The material of the door, metal or wood, was recognised correctly. The intermediate wood texture was at times confused with smooth wood or rough wood (53.5% of the time). Overall, by combining these results and findings from previous research (see §3.2.1), the following doors were selected to be utilised in the audiovisual experiment: RIW for anger, YRW for fear, BM for happiness, GSW for neutral, BrwM for sadness.

4.2 Audiovisual experiment

We found a significant relationship between the intended emotion of the knocking action sound and the perceived overall emotion $\chi^2(16, N = 1050) = 803.651, p < .01$. There is no statistical significant difference between results for anger and fear. This confirms results from our previous study [6] from which the knocking actions where selected. Happiness, sadness and neutral are recognised correctly with statistical significance (see Figure 3).

There is no significant relationship between the doors' intended emotions and the perceived overall emotions $\chi^2(16,$
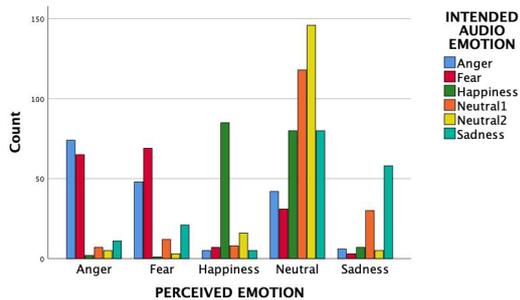
Figure 3. Audiovisual experiment: Perceived emotion vs intended audio emotion.

N = 1050) = 20.666, p > .05. The visual characteristics of the doors do not contribute to the overall emotional perception of these audiovisual stimuli. The sound of the knocking action, on this occasion, dominates the overall perceived emotion. In regard to congruent audiovisual stimuli (i.e. where the intended emotions for audio and visual aspects coincide), they do not seem to be significantly more expressive, however we note that the RIW door combined with the angry knock has the highest number of responses for perceived anger; the BrwM door combined with the sad knock reports the second highest number of responses for perceived sadness (GS with sad knock reports the highest); the BM door combined with the happy knock reports the second highest number of responses for perceived happiness together with BrwM with happy knock (RIW with happy sound has the highest number of responses). Finally, the intended emotions of the doors such as anger, fear, happiness and sadness do not come through more strongly in the overall perceived emotion when the knocking sound´s intended emotion is neutral.

5. DISCUSSION

Results from the pre-study are consistent with trends found in previous studies on the association between colours and emotions. More specifically, high-arousal emotions are often matched with warmer colors like red and yellow [19, 20, 22, 23], or highly saturated colours [14, 19, 28]. Our results also confirm the complexity of the area. While associations between single emotions and a few colours were detected, no one-to-one associations between emotional states and colours. We suggest that if one-to-one colour-emotions associations exist, they might require a larger sample size to detect them. The most important result from the audiovisual experiment is the dominance of the aural modality on the perception of the overall emotion. It appears that, in this case, the audio drives the emotional state evoked in the subjects, a conclusion which, we speculate, could be due to the different implied sources of the audio and visuals respectively. While a knocking sound would usually imply the presence of a human as its source (i.e. an agent experiencing emotions), the colour and material of a door are features of an inanimate object that does not experience emotions (although we might project our

emotions onto this object). We therefore suggest that, in this case, the emotion behind an human action, here portrayed by the audio modality, bears more importance than the emotion evoked by the door. This might tell us that, in the context of filmmaking, for example, Foley performances contribute more than we think to the overall storytelling experience, and should perhaps be considered with the same attention traditionally granted to other visual aspects of the process (e.g. production design). In regard to congruent and not congruent stimuli, we did not find significant results. However looking at absolute number of responses for some emotions congruence suggests an increase in effect. With a larger study the presence of such small effects might be confirmed.

6. CONCLUSIONS

With the goal of exploring the perception of emotion in audiovisual representations of everyday actions, and building on previous research in the field, we have conducted two experiments. These enabled us to investigate how basic emotions can be evoked through a combinations of audio and visual features, and assess the impact that the different modalities have on the perceived emotions. Overall, the results provide a basis to help us understand how different aspects of an audiovisual artifact might contribute to the formation of an overall emotional experience in an audience. Further work could include investigating the impact of several other features on the perception of emotions. For example, point-light animations of the knocking hand could clarify the point of view and point of audition, door size, and audio and visual contextual elements could be added to the investigation. Furthermore, a wider range of emotions could be investigated, perhaps using different frameworks such as arousal-valence, as well as the impact of different immersive playback environments (cinematic, VR, gaming environment, etc.) on the perception of emotions in audiovisual stimuli.

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