A situated experimental protocol to study emotional responses to an interactive object

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Abstract

We report on an experiment aimed to measure emotional reaction to an object prototype: an intelligent surgical mask reacting with color to its bearer's cough and sneeze sounds. Rather than attempting to yield generic conclusions on the emotional impact of colors, we reproduce the specific situation of a user interacting with the object, its sound, color, semantic context and time dynamics. We collect emotional ratings along the 3 dimensions of valence, arousal and potence, using the Self-Assessment Manikin methodology. Our results show that (1) our protocol yields consistent results and can be used to inform the design choice of the ideal color for the object; and (2) that the emotional reactions to the colors presented in such a specific, multimodal context differ significantly from what could be predicted using more generic, non-situated studies.

Key words: *Emotion, Color, Context, Self-Assessment Manikin, Situated, Design*

Introduction

Designers and scientists alike want to elucidate the mechanisms of human emotions. Recent research identifies emotions with states of bodily arousal, detected by the brain, and evoked in reaction to stimuli provided by the environment [Damasio, 1999]. In this view, the object of study is the organism's internal psycho-physiological system; the environment (which includes objects, social context, etc.) is an unwanted source of variability, which needs to be controlled experimentally.

However well-principled, this methodology contradicts a basic intuition of design: the emotional response of a user to a designed artifact depends on their interaction; kansei is *situated* rather than *provoked* by the situation. For the designer, choosing pleasing visual features for an object is necessarily specific to the rich, time-evolving situation that it affords. It is unclear whether generic psychoacoustic results can inform this choice.

The paradox is particularly noted in color research, where two trends of research are difficult to reconciliate: one uses ecologically-valid stimuli, such as the colors of store design [Bellizzi & Crowley, 1983]; the other, laboratory constructs, such as color chips [Taft, 1997] or printed stimulus sheets [Suk & Irtel, 2010]. Whether emotional reactions to both kinds of stimuli is different, and how, is the object of considerable debate. On the one hand, studies like Task (1997) established that presenting color on neutral chips or on well-identified objects such as cars or table did not yielded significant changes – which justifies a long history of research done in laboratory conditions. On the other hand, several studies have produced anecdotal evidence that context may over-rule generic trends. For instance, while warm colors such as red or yellow are typically associated with positive emotional valence, Bellizi & Crowley (1983) showed that subjects perceived warm-colored work environments as less attractive and less pleasant than cool-colored environments.

This article deliberately situates color reactions in their specific context. More precisely, we describe an experimental protocol to measure emotional responses to a very specific object: a surgical pandemic mask able to

Figure 1 Concept sketches for the "hearing mask", after a joint student workshop between Tsukuba University (students: Liao Sha, Sai Shao) and Temple University (Katy Gates, Kenta Shibasaki, Manda Becker.)

automatically detect when its bearer coughs and sneezes and to react to the sound by instantly changing color. The purpose of the object prototype is to explore how automatic color reactions to sounds can soften the negative impact of such sounds in its surroundings – certainly coughing is perceived very negatively in these times of influenza pandemics. The concept of this "hearing mask" in the outcome of a series of student brainstorms conducted in collaboration between Tsukuba University and Temple University, Japan Campus from September to December 2009 (Figure 1).

In a typical psychophysics way, a majority of color research collects emotional ratings using a combination of word scales, subjects them to factor analysis to identify relevant dimensions and correlates them with the physical dimensions of color stimuli (e.g. wavelength). In this work, we use a different measurement method, namely the Self-Assessment Manikin SAM (Bradly & Lang, 1994). SAM ratings are collected over 3 non-verbal scales of emotional response: valence, arousal and potence, each described by a graded series of pictograms, as illustrated in Figure 2. The SAM method is reliable across cultures, and produce ratings independently from the lexical semantic associations introduced by words.

Methods

Stimuli

39 colors were chosen for the test, based on the Munsell system of hue (the gradation of color), value (lightness or darkness of the hue) and chroma (degree to which the

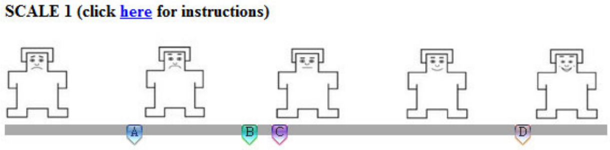

Figure 2. Self-Assessment Manikin scale for rating the valence of an emotional response, ranking from very negative to very positive.

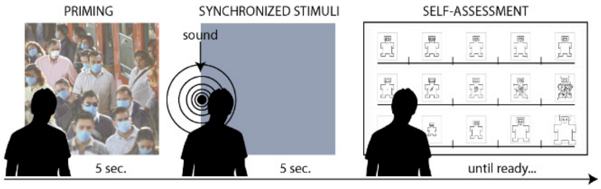

Figure 3 The experimental design reproduces the situation of interacting with the object, using a combination of visual and audio stimuli, presented in a fixed timing.

hue is saturated). We selected the 5 hues *blue, yellow, green, red, and purple*. From each hue, we generated a total of 8 stimuli, each with 4 degrees of values (1,3,5,8) and 2 degrees of chromas (2,6). In addition to colors, we used a single sound recording of a man coughing (2 second, mono, 44,1kHz 16bits), obtained from the FreeSound project (http://www.freesounds.org).

Task

Participants were presented with an automated slideshow on a computer desktop, hearing sound through a pair of headphones. Each subject saw a series of three slides per each color (Figure 3). In the first slide they were presented with a picture of many people wearing masks, priming for the semantic context of an influenza epidemic. The picture is presented for five seconds. The second slide is a full color screen, with one of the randomly selected color from the set of 40, accompanied on onset with the sound stimuli, and lasting for a total of five seconds. On the third slide, participants were prompted to rate the color that they had just seen, using the SAM. This process was repeated for a total of 39 times.

Participants

16 subjects participated, all relatively young (M = 21) American undergraduate students (10 male and 6 female). Each participant was asked to rate the emotional content of the situation described above for all 39 colors, resulting in 16(participants)*3(scales)=48 series of 39 data points. 7 series were removed as outliers.

Results

Rating consistency

The means (M=4.15) and standard deviations (M=1.93) of the collected ratings were found to be comparable in the 3 dimensions of valence, arousal and potence. Across all color stimuli, female participants tend to make higher judgments than male for the dimension of valence (M=4.28 > 3.87), but lower for both arousal (M=3.89 < 4.35) and potence (M=3.71 < 4.66). No trend of gender effect is seen on standard deviations in any of the dimensions.

On the whole, the color that was rated with most positive valence and arousal, hence arguably the best candidate for the mask design, is a dark nuance of blue, B516. The "worst" color, with negative valence and arousal, Y512, a green nuance of yellow.

Effect of hue categories

Figure 4 shows the average scores of valence, arousal and potence, grouped by all 5 color hues, and further broken down by participant gender. Yellow is the hue with most negative valence, and blue is most positive. This is consistent with the literature, which identify e.g. blue as the most common "favorite" color in the western world (Suk & Irtel, 2010). More surprising is the low valence observed for green, which is yet typically associated with positive values of nature and relaxation. Similar surprising results are seen on the arousal scale, where a typical warm, high-excitation (long wavelength) color as red is judged consistently lower arousal than green, yet a colder color.

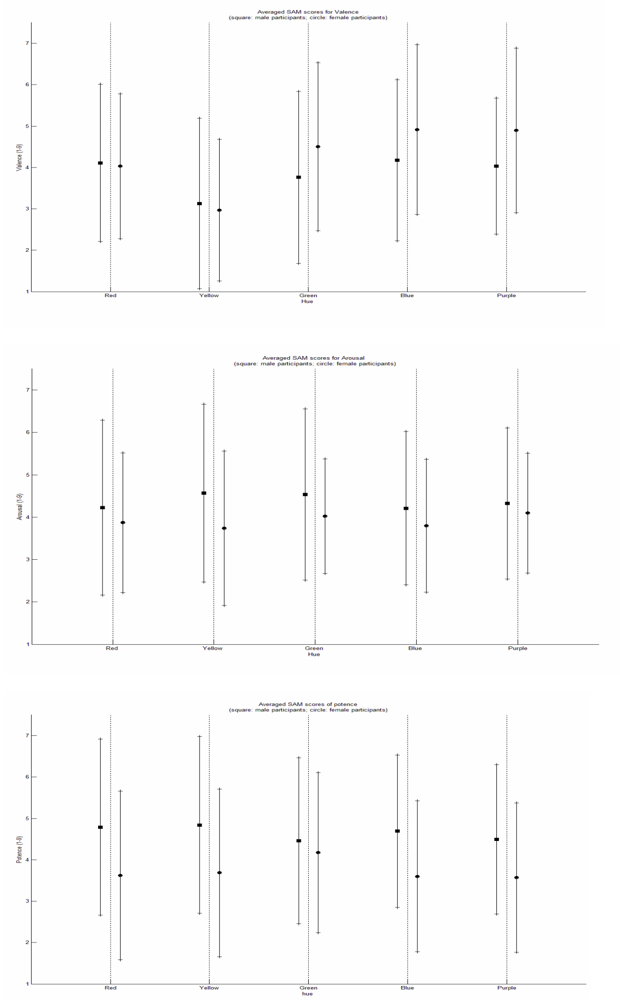

Figure 4. Influence of color hue on ratings of valence (top), arousal (middle), potence (bottom), broken down by participant gender (left: male, right: female)

Effect of chroma degrees

Figure 5 shows the influence of increasing color chroma on ratings of valence, arousal and potence. Valence results are in accordance with the literature (see e.g. Suk & Irtel, 2010), showing a positive regression of valence on increasing chroma. However, whereas Suk & Irtel (2010) note the same positive correlation for arousal and potence, our results show strong gender effects, with clear negative correlations on both dimensions for female participants – something we could not relate to any observation in previous literature.

Conclusion

Our results show that it is possible to determine a best color for our specific design concept with this methodology. Colors are statistically significantly different from one another, on all 3 SAM dimensions. Moreover, emotional effects can be regressed on both hues and chromas, although it is noted that the two effects are not independent (2 taints of e.g. blue can be

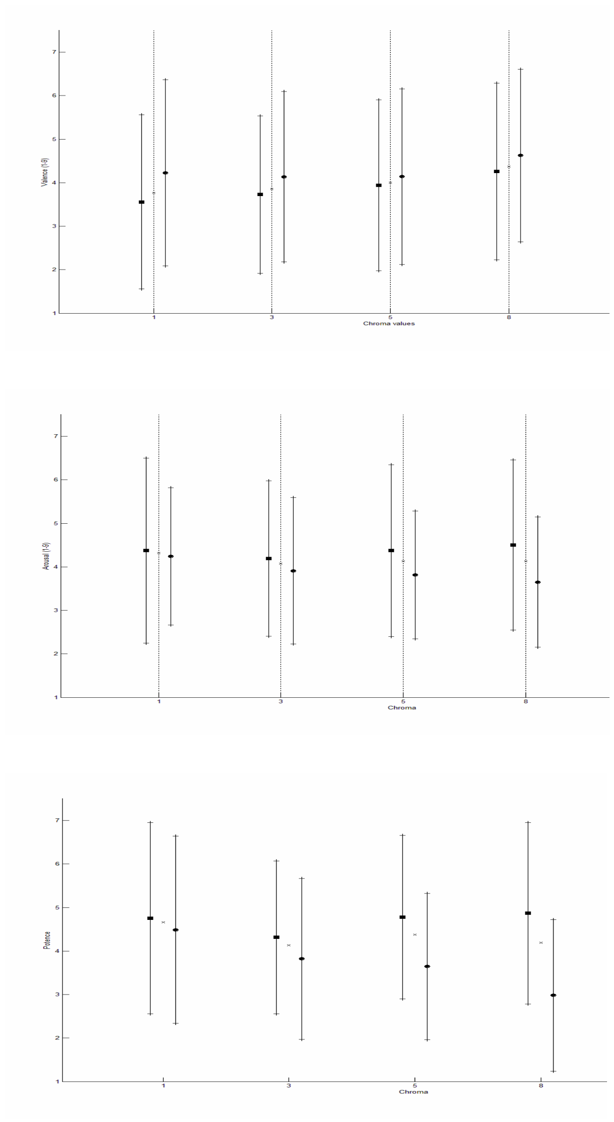

Figure 5. Influence of increasing chroma on ratings of valence (top), arousal (middle), potence (bottom), broken down by participant gender (left: male, right: female)

significantly different, and not equally good candidates for the object's color).

Results obtained with our situated protocol deviate significantly from the typical color reactions noted in the literature, with more generic experimental situations. Green is usually a positive valence color, but it is judged here as negative. One possible explanation is that it is perceived to be associated with sickness and body fluids, hence its perception is "primed" by the semantic context of the experiment (influenza and cough). This is a high-level cognitive effect, which can probably be observed with many different objects and situations. Other differences are more difficult to relate to semantic effects, such as red being judged as low arousal. These may results from lower-level psychophysics: the sudden onset of the sound stimuli, as well as the specific timing of the visual presentation may effect on the perception of arousal, much as e.g. motion effects on the perception of sound (McGurk & McDonald, 1976). More work is needed to test for such mechanisms (vary timing, vary sound stimuli, remove sound, etc.).

On the whole, we believe our observations are evidence that situated emotional reactions to a designed object cannot be easily predicted by generic results obtained in non-situated laboratory conditions. The fact that such effects were ruled out in some previous literature (e.g. Taft 1996) can be explained by the fact that context activation needs more than a static object reference (e.g. a blue car instead of a blue color chip), but rather should incorporate elements of action, semantics and timing (here, cough, influenza, quick activation of the color synchronized with sound). More expertise should be gained as a community on designing such dynamic, strongly-contextual experimental set-ups, as this has potential to inform better design decisions and to advance our understanding of human emotions.

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