Oral Session I: Theory and Practice of Design

Analysis of Emotional Responses to Dot Patterns Using Physiological Measurement

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ABSTRACT

To explore emotional responses while observing dots placed on the human face, we examined how the pupils respond to dot patterns (i.e., clusters of dots) placed on the human face or on the gray background image. The participants were instructed to view an image of a face or a uniform gray square with/without dot patterns on it while pupillary responses were recorded. The results showed that transient pupil constrictions occurred in response to dot patterns on the human face at around the first 0.5–1.0 s, and pupil dilation was sustained thereafter. The changes in the pupil size suggest that we may simultaneously have two kinds of emotions, disgust and fear, or disgust and a positive emotion, to dot patterns on the face.

1. INTRODUCTION

Although patterns of figures, such as dot patterns are used as common decorative elements in visual design and daily products (e.g., curtains), some researchers reported that observation of dot patterns can induce discomfort (Cole & Wilkins, 2013). Interestingly, placing dot patterns on the human face increase discomfort significantly. This is called HASU-COLLA (HASU=lotus seed pods; COLLA [i.e., collage] = photomontage image). The discomfort to the dot patterns was originally thought to fear (Cole & Wilkins, 2013) but a recent study suggests that it could be disgust (Imaizumi et al., 2016). Although fear or disgust have considered as main emotional responses at the observation of dot patterns in recently documented physiological and psychological studies, it is not clear which emotional response dominates at the observation of dot patterns.

Physiological studies have shown that the human pupils change while viewing affective pictures, suggesting that the pupils constricted to disgusting images (e.g., contaminated and violent scenes) and they dilated to attractive or fearful images (e.g., erotic scenes) (Bradley et al., 2015; Hess & Polt, 1960). A recent study (Ayzenberg et al., 2018) reported that sustained pupils constricted to images of a group of holes within five seconds comparing with fear and neutral stimulus. This response was thought to be associated with disgust, not fear. However, physiological responses to the dot patterns are unknown. Therefore the present study aims to explore emotional responses during the observation of dot patterns on the human face and gray background image using pupillometry.

2. METHOD

2.1 Participants

Five adults (2 males and 3 females; mean age = 34±13.8 years) participated in the study. All participants had normal or corrected-to-normal vision. The experiments were conducted according to the principles of the Declaration of Helsinki and approved by the Ethics

Committee of the Graduate School of Art and Design, University of Tsukuba (Approval Number 29-11).

2.2 Stimuli & Apparatus

The 32 stimuli images were of four types: (a) dots on the human face (DOF), (b) dots on the uniform gray background image (DOG), (c) human face only (F), and (d) gray background image (G) as shown in (Figure 1). The human face images of eight frontal Japanese faces (four females and four males) were taken from Japanese and Caucasian Facial Expressions of Emotion (JACFEE) (Biehl et al., 1997). For the DOG images, we duplicated the same dot patterns that were used for the DOF images and presented dot patterns centrally on the uniform gray background images. All images were presented with the same brightness (mean grayscale value = 106, mean luminance = 9.23 cd/m^2, room light = approximately 913 lx) using Adobe Photoshop and SHINE toolbox for Matlab (Willenbockel et al., 2010). The image sizes were 48.5°×27.3°. Pupillary responses were recorded using the Tobii Pro TX300 eye-tracker (1920 × 1080 pixels, 300 Hz, Tobii Technology, Sweden).

2.2 Procedures

The experiment was conducted in a bright room (approximately 913 lx). Each participant was seated in a chinrest 60 cm from the screen. They were instructed to minimize body movements and keep their gaze directed toward the screen during viewing. Thirty-two trials (8 DOG, 8 G, 8 DOF, and 8 F respectively) were conducted in a randomized order. Each trial consisted of a 6 s fixation phase and a 6 s image phase. Each trial began with a fixation phase, followed by an image phase. For each trial, a 1 s pre-image phase baseline average was served as the pupillary baseline.

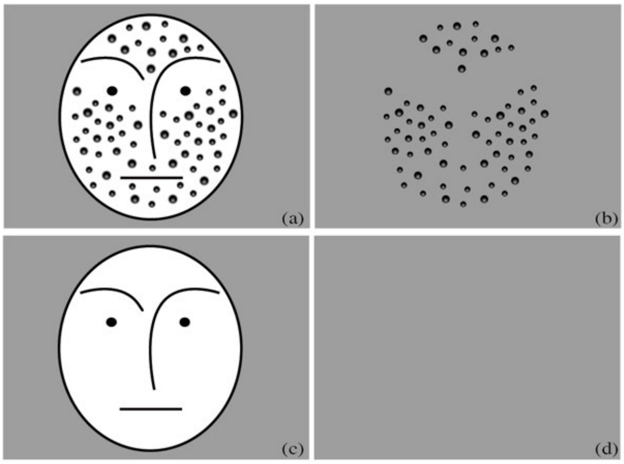

Figure 1: A simplified illustration of (a) dots on the face (DOF), (b) dots on the gray background image (DOG), (c) human face only (F), and (d) gray background image (G). All images have the same brightness (mean grayscale value = 106, mean luminance = 9.23 cd/m^2, room light = approximately 913 lx).

3. RESULTS

The mean percentage changes in pupil size during the image phase from each pupillary baseline were analyzed. A two-way repeated measure analysis of variance (ANOVA) revealed a significant main effect of time F (59, 2124) = 15.460, p < .001, ηp^2 = .30, and a main effect of stimulus type F (3,108) = .856, p = .466, ηp^2 = .023 (Figure 2 (a)). These main effects were qualified by the predicted interaction between stimulus type and time, F (177,

6372) = 2.58, $p < .001$, $\eta p^2 = .067$. Analyses of variance (ANOVAs) conducted for each time point with stimuli type as a factor and corrected for least significant difference (LSD) demonstrated that reductions in pupil size in response to the DOG were significantly greater than those to G (*ps* < .001, DOG < 0,G > 0) between 0.5–1.0 s; F than to DOF (*ps* < .05, DOF > 0, F > 0) at 2.3 s; and G than to DOG (*ps* < .05, DOG > 0, DOG>G) between 3.7–4.1 s, suggesting that pupil changes were greater in response to images with dots than images without dots.

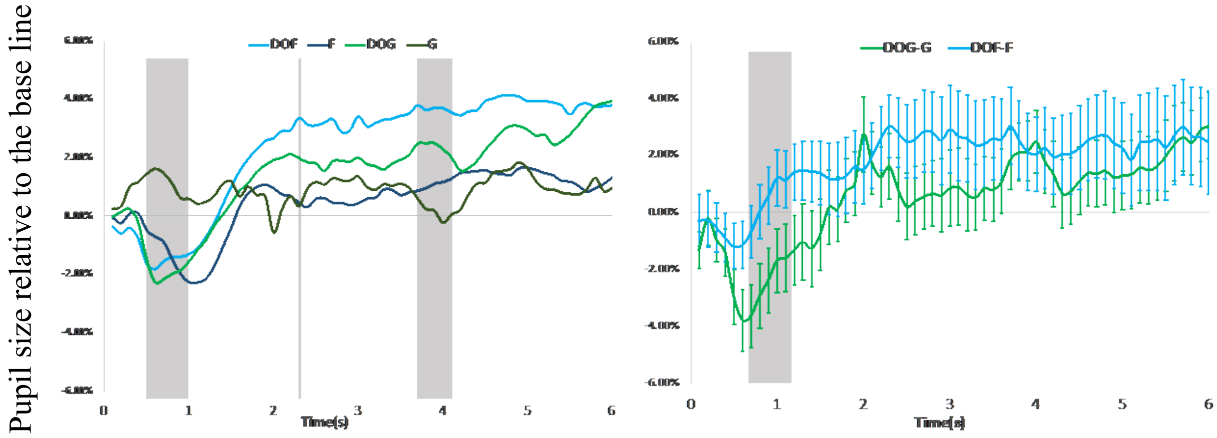

Figure 2: Pupillary waveforms reflect the percentage changes of pupil size from baseline. The x- axis represents trial time in seconds (s), and the y-axis represents the percentage changes of pupil size relative to the baseline. The negative percent represents pupil constriction, whereas positive ones represent pupil dilation. Vertical line represent the standard error of the mean (SEM). The rectangular gray regions represent (a) from left to right, greater pupil constriction to DOG than to G during 0.5 –1.0 s (ps < .001); F than to DOF at 2.3 s (ps < 0.5); G than to DOG at 3.7–4.1 s (ps < .05); (b) greater pupil constriction to the DOG-G than to DOF-F at 0.7–1.2 s (ps < 0.5).

To assess the dot effect in different background images (i.e., F vs. G), we compared the simple effect of the difference between DOF and F (i.e., DOF-F) and the difference between DOG and G (i.e., DOG-G) (Figure 2 (b)). Paired samples t-tests demonstrated a greater reduction in pupil size in response to the DOG-G than to the DOF-F (*ps* < .05, DOG-G < 0, DOG-G < DOF-F, 1.4s: p=0.05) between 0.7–1.2 s, which suggested a greater reduction in pupil size in response to dots placed on the gray background images between 0.7–1.2 s.

4. DISCUSSION AND CONCLUSION

In this study, we examined how the pupils responded to the images of dot patterns placed on the human face and gray background images. Our results showed that there was a reduction in pupil size (Figure 2(a)) between 0.5–1.0 s during the image phases of dots on the gray background image (i.e., DOG) compared to those without dots (i.e., G). However, there was an increase in pupil size between 3.7–4.1 s and at 2.3 s during the image phases with dots (i.e., DOG and DOF) compared to those without dots (i.e., G and F). For the evaluation of dot effect, the reduction in pupil size between 0.7–1.2 s (Figure 2(b)) in response to the image of dots on the gray background image (i.e., DOG) was compared to the image of dots placed on the human face (i.e., DOF). The results showed a greater pupillary response to the images with dot patterns (i.e., human face and gray background image) than those without, while dot patterns on the gray background made more pupil constriction than dot patterns on the human face during the first 1 second, although participants felt more disgust to dot patterns on the human face. During the following seconds, however, the results indicated significant reduction in pupil size to dot patterns on the human face. Taken together, the results suggest that we may simultaneously have two kinds of emotions such as disgust and fear, or disgust and a positive emotion such as being attracted. This study provides preliminary observational data indicating pupillary responses to dot patterns on the human face. Future research will involve more subjects so that it may contribute to a better understanding of a relationship between emotional responses and dot patterns.

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