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Effects of Emotional Valence (Positive or Negative Visual Images) and Arousal Levels (High or Low Arousal Levels) on the Useful Field of View

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Abstract

One of two emotional valence (positive or negative) images and two arousal (high or low) images was presented for 500 ms to participants. After the image vanished from the screen, a letter was presented in the central visual field, while a number was also presented in one of the peripheral visual fields (upper right, upper left, bottom right, and bottom left). There were four conditions of degree of eccentricity of the presented number. The participants identified both the letter and number simultaneously. By calculating the correct performance rate of the peripheral identification task, the range of the useful field of view (UFOV) was speculated. Results showed that performance rates of the central and peripheral tasks were worse for the high arousal, negative emotion stimuli compared with the other three conditions. Moreover, performance rates of the peripheral task were better for the positive emotion conditions than those for the negative emotion conditions when the stimulus eccentricities were 3 or 12 degrees. We concluded that the range of the UFOV could be affected by the interaction between the emotional valence and arousal level of visual stimuli. This study was the first report that emotional valence and arousal level interacted each other and did affect our human visual cognition.

Keywords

Central, Peripheral, Arousal Level, Emotional Valence, Positive, Negative, Useful Field of View (UFOV)

1. Introduction

When humans observe fearful things, negative emotions are evoked. Similarly, when we see enjoyable or pretty things, positive emotions are evoked. Such emotions can be divided into four types, consisting of two emotional

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valences (positive and negative) and two arousal levels (high and low) (Barrett & Russell, 1999; Bradley, 1992). Arousal level refers to an index that indicates the level of emotion. Emotion affects human perception, cognition, and attention (e.g., Anderson & Phelps, 2001; Sussman et al., 2013).

Previous studies have reported that emotional valence and arousal level interact with each other. Nobata and Ochi (2005) reported that arousal levels in both positive and negative emotional valences can affect memory task performance. High arousal positive images inhibit memory task performance more than low arousal positive images, while high arousal negative images facilitated memory task performance more than low arousal negative images.

In addition, some studies have reported that negative images facilitated or inhibited memory tasks compared with neutral emotional valence images. One theory that attempts to explain these results is the attentional focusing hypothesis (Christianson, 1992).

The attentional focusing hypothesis states that high arousal negative images facilitate the information which is "central" but inhibit the "peripheral" information. However, this hypothesis does not clearly define what should be considered "central" and "peripheral". We have at least two definitions of central and peripheral, i.e., semantically central and peripheral information and physically central and peripheral positions in the visual field.

Christianson and Loftus (1991) and Burke et al. (1992) have done work supporting the attentional focusing hypothesis. Burke et al. (1992) examined the abovementioned four types of visual images: semantically central and peripheral, and also physically central and peripheral. They examined the correct recognition and memory of these four types of visual information. Their results revealed that both semantically and physically peripheral information could not be memorized as correctly as central information. In this article, therefore, we focus on the role of attentional aspect of the attentional focusing hypothesis. We hypothesize that of the four types of visual information, negative high arousal images can be memorized most accurately because they are the type of image that gathers the most attention.

Fredrickson (2001) reported that negative images are more effectively memorized. Calvo and Lang (2005) reported that emotional images gather relatively more attention. In addition, Bradley (1994) reported that this effect of gathering attention was not dependent on whether the images were negative or positive.

Some previous studies have reported that compared with positive images, negative images were more likely to make the useful field of view (UFOV) narrower (e.g., Nobata et al., 2010). The reason for this finding is thought to be that negative images are much more likely to gather one's attention than positive images.

In the current study, we measured the width of the UFOV as the index of the degree of attention gathering. We examined the effects of both the arousal level and emotional valence of images on the width of the UFOV. Nobata and Ochi (2005) reported that arousal levels can alter memory task performance. They reported that high arousal negative images were more correctly memorized than low arousal negative images, and also that high arousal positive images were memorized less accurately than low arousal positive images. Therefore, it seems that arousal level and emotional valence interact with each other.

We examined the effects of emotional valence (positive or negative) and arousal level (high or low) on UFOV width. We measured UFOV width by presenting participants with a 2 × 2 grid of the four possible image types. Here, UFOV is defined as the region of the visual field from which an observer can extract information at any time (Sekuler et al., 2000).

We used IAPS (International Affective Picture System) as stimuli. IAPS has been repeatedly used in psychological research for examining the effects of arousal level and emotional valence (e.g., McManis et al., 2001; Bradley et al., 2001).

We set four degrees of eccentricity in which the stimuli were presented. By calculating correct performance of the peripheral task, we could speculate the range and width of the UFOV. Our hypothesis was that high arousal negative images would cause the UFOV to become the narrowest because it would most effectively gather the attention of the participants, and, by the same logic, that high arousal images would also make the UFOV narrower.

2. Methodology

We presented the participants with high or low arousal, and also positive or negative, images from IAPS. Then we measured the width of the UFOV using dual letter identification tasks.

2.1. Ethics Statement

The experiment was pre-approved by the Kurume University Ethics Committee, and informed written consent was obtained from each participant before testing.

2.2. Participants

Twenty-four graduate and undergraduate students (8 males, 16 females) who were naïve to the true nature of the experiment participated in the experiment. Their mean age was 21.7 years old (SD 1.63). They had normal or corrected to normal vision.

2.3. Stimulus and Apparatus

Stimuli were generated and controlled by computers (VPCL12AFJ, Sony) and presented on a 21.5 inch monitor (PCG-11212N, Sony). The experiment was conducted in a dark chamber. The experimental procedure was controlled by SuperLab 4.5 software (Cerdus Corporation).

In total, 80 images were selected from the IAPS (International Affective Picture System; Lang, Bradley, & Cuthbert, 2008) as stimuli. There were 4 conditions: high arousal and positive images, high arousal and negative images, low arousal and positive images, and low arousal and negative images. For each condition, 20 images were used. The average valence and arousal levels for each condition are presented in **Table 1**. The IAPS images used in this study were shown in the footnote[1].

The head of each participant was fixed using a chin rest from a viewing distance of 57 cm. First, a fixation point was presented for 500 ms. Then, a stimulus image was presented for 500 ms before disappearing. The screen was then blank for 200 ms, after which a letter of the alphabet (D, F, K, or L) was presented in the central visual field. The participants were instructed to respond by pressing the key on the keyboard that corresponded to the alphabet letter they had viewed. There was also a simultaneous peripheral task, in which a number (1, 3, 4, or 7) was presented. There were four degrees of eccentricity in the presentation of this number, i.e., 3, 6, 9, or 12 degrees away from the center of the screen; in addition, each number was presented in one of the four possible directions from the center (upper right, bottom right, upper left, or bottom left). Out of the 80 trials, the number was not presented in 20 trials because they were treated as dummy trials. **Figure 1** illustrates an experimental

Table 1. Ratings of stimulation levels of images used in this study.

	Emotional valence (SD)	Arousal level (SD)
Low arousal positive	7.07 (0.43)	4.06 (0.07)
High arousal positive	7.08 (0.47)	6.75 (0.37)
Low arousal negative	3.17 (0.46)	4.11 (0.32)
High arousal negative	2.77 (0.56)	6.69 (0.35)

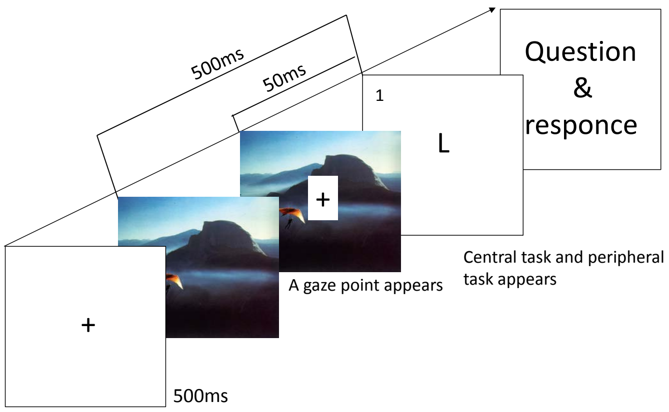

Figure 1. Schematic illustration of experimental trial.

[1]Low-arousal positive condition (1410, 1600, 1610, 2170, 2222, 2314, 2341, 2387, 2510, 2530, 4622, 4700, 5593, 5594, 5611, 5991, 7238, 7530, 8032, 8330), high-arousal positive condition (1650, 4220, 4607, 4659, 4668, 5621, 5629, 7650, 8030, 8163, 8178, 8179, 8185, 8186, 8200, 8341, 8400, 8490, 8492, 8501), low-arousal negative condition (2039, 2399, 2490, 2590, 2682, 2718, 2722, 2750, 9000, 9001, 9008, 9090, 9220, 9265, 9290, 9291, 9331, 9341, 9390, 9832), high-arousal negative condition (1050, 1052, 1120, 1300, 1304, 1930, 2811, 3500, 6021, 6230, 6250.1, 6260, 6263, 6510, 6540, 6550, 6560, 8485, 9620, 9904)

trial. By calculating the correct performance of the peripheral task, we could speculate the range and width of the UFOV. We speculated that the higher correct performance in more peripheral numbers indicated that the wider UFOV *vice versa*.

We obtained the correct performance rates of the central and peripheral tasks. The performance rates were then transferred using angular transformation.

3. Results

3.1. Central Task Performance

We conducted a two-way ANOVA on the performance rates and reaction times (RTs) of the central tasks for all trials in which a number was shown. We eliminated all RTs that did not fall within three SDs of the mean RTs.

For the correct answer rate of the central task, the main effect of emotional valence was significant (F (1, 25) = 15.96, p = 0.001). Multiple comparisons (Ryan's method) revealed that performance was better for positive images than that for negative images ($p < 0.05$). However, the main effect of arousal was not significant (F (1, 25) = 0.25, p = 0.622). The interaction between emotional valence and arousal level was significant (F (1, 25) = 6.44, p = 0.018). Multiple comparisons revealed that for high arousal images, performance was better for positive images than that for negative images ($p < 0.05$). For negative images, performance for high arousal images was worse than that for low arousal images ($p < 0.10$). The results are shown in **Figure 2**.

As for the RTs of the central task, the main effects for emotional valence and arousal level were significant (F (1, 25) = 11.98, p = 0.002; F (1, 25) = 5.74, p = 0.024). Multiple comparisons revealed that RTs to positive images were significantly faster than those to negative images. Moreover, RTs to low arousal level images were significantly faster than those to high arousal images. The interaction between emotional valence and arousal level was not significant (F (1, 25) = 0.13, p = 0.727).

3.2. Peripheral Task Performance

We deleted from the analysis those trials in which the central task was not correctly performed because this could not guarantee that the participants' gaze direction was correctly fixed at the central visual field during the conducting of the dual tasks. We conducted a three-way ANOVA on the performance rates. The results are shown in **Figure 3**.

The main effects of emotional valence and arousal level were significant, and the main effect of the eccentricity showed a tendency toward significance (F (1, 25) = 6.11, p = 0.021; F (3, 75) = 21.59, p = 0.000; F (1, 25) = 3.19, p = 0.086). Multiple comparisons (Ryan's method) revealed that performance was better for positive images than for negative images; moreover, performance was also better for low arousal images than for high arousal images. The interaction between emotional valence and arousal level was significant (F (1, 25) = 5.12, p = 0.033), and the interaction between emotional valence and eccentricity showed a tendency toward significance

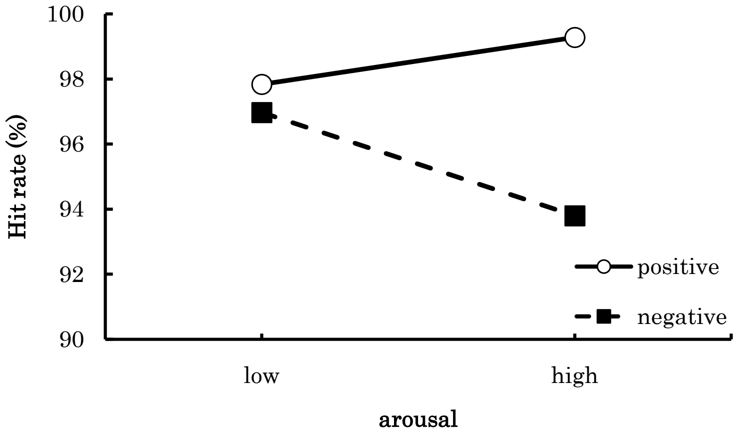

Figure 2. Average correct performance rates for the four conditions: positive low arousal, positive high arousal, negative low arousal, and negative high arousal.

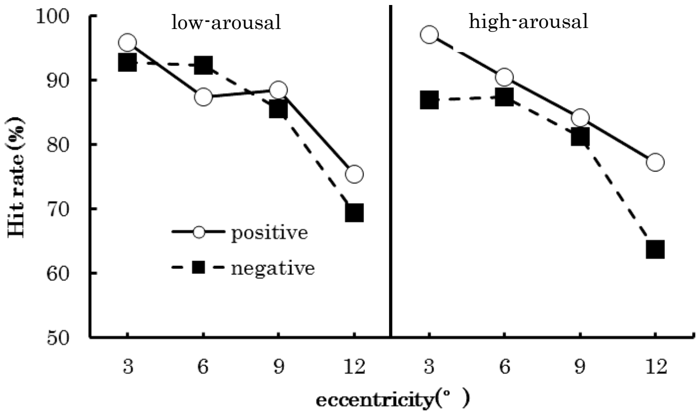

Figure 3. Average correct performance rates for all conditions at each level of eccentricity.

(F (3, 75) = 2.41, p = 0.074). However, the interaction between arousal level and eccentricity was not significant (F (3, 75) = 0.48, p = 0.699), and the interaction between emotional valence and arousal level and eccentricity was not significant (F (3, 75) = 0.57, p = 0.637). Multiple comparisons revealed that for high arousal images, performance was better for positive images than for negative images ($p < 0.01$). For negative images, performance for high arousal images was worse than that for low arousal images ($p < 0.01$). Multiple comparisons revealed that in the 3 and 12 degrees eccentricity trials, performance was better for positive images than that for negative images ($p < 0.05$, $p < 0.01$). For positive images, performance was worse in the 12 degrees condition than that in the 3, 6, and 9 degrees conditions ($p < 0.10$). In addition, performance was also better in the 3 degrees condition than in the 6 and 9 degrees conditions. For the negative image conditions, performance in the 12 degrees condition was worse than that in the 3, 6, and 9 degrees conditions ($p < 0.10$) (We thought that the higher correct performance in more peripheral identification task indicated that the wider UFOV *vice versa*).

4. Discussion

We examined the effects of emotional valence (positive or negative) and arousal level (high or low) on dual tasks in the central and peripheral visual fields.

Regarding the task performed in the central visual filed, performance was sufficiently high (over 90% correct) to guarantee that fixation was indeed fixed in the central visual field. In the central task, performance was better for positive images than for negative images, while for negative images, performance on high arousal images was worse than that on low arousal images. RTs were longer for negative images than for positive images. This result corresponds well to the results of previous studies (e.g., Sussman et al., 2013). Performance was the worst for negative high arousal images.

As for the peripheral task, performance was significantly worse in the negative 12 degrees condition. This result suggests that negative images caused the UFOV to become the narrowest. This result also corresponds well to the results of Nobata et al. (2010).

The interaction between emotional valence and arousal level was significant in the peripheral task. Performance was worse for high arousal negative images than for the corresponding positive condition. Thus, we observed effects of emotional valence and arousal level. According to our results, high arousal negative images seemed to most effectively gather attention. This attention gathering was likely the reason for our result which found the performance for negative high arousal images to be the worst overall. This result also corresponds well to the results of a number of previous studies (e.g., Sussman et al., 2013; Small et al., 2011; Jefferies et al., 2008).

Jefferies et al. (2008) examined the effects of the same four types of visual images on attentional blinking. They showed that attentional blinking most frequently appears when presented with high arousal negative images and that it appears less frequently when presented with low arousal images. Both their results and the results of the current study correspond well, adding further support to the conclusion that there is an indeed an interaction between arousal level and emotional valence in human visual perception, i.e., attentional capture.

5. Conclusion

In this study, we reported that the UFOVs were made narrower by the presentation of negative images compared with the presentation of positive images, and also that arousal level had a stronger influence on performance of identification tasks when the images were negative. The range of UFOV could be within 9 degrees when the stimuli were negative images, but it could be wider (at least 12 degrees wide) when the stimuli were positive images. We could therefore conclude that high arousal negative images most efficiently captured the attention of the participants.

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