ENHANCED REPETITION BLINDNESS WITH ANGRY EMOTIONAL FACES

Kao YAMAOKA1) and Satoshi UMEDA2)

1) Sophia University, Japan
2) Keio University, Japan

Repetition blindness is defined as difficulty detecting repeated targets within an array of stimuli. However, it is unclear how emotion affects this phenomenon. In the present study, participants were exposed to happy and angry faces, and non-emotional stimuli shown in rapid serial visual presentation. They were required to identify the repeated targets, and the magnitude of repetition blindness was measured to indicate emotional effects. Analysis showed that, while there was no difference in accuracy between happy and angry faces on non-repeated trials, accuracy was significantly lower for angry faces on repeated trials inducing greater repetition blindness. This effect was stronger when the stimulus exposure rate was 150 msec, suggesting its early processes and strong capturing of attention. These results show that repetition blindness effect was stronger with angry faces, which is likely due to enhanced emotional alertness and increase in intensity of the processes inducing greater repetition blindness.

Key words: visual attention, repetition blindness, emotional faces

Emotions are responses to external stimuli and/or internal mental representations. They differ from moods in that they are often associated with their own identifiable objects or triggers (Ochsner & Gross, 2005). Intrinsically emotional stimuli can elicit emotional responses, some of which are innate and others of which are learned. The human face is one of the most common triggers of emotional responses, and many studies have been published on perceptual and biological significance of the human faces compared with other objects (Fox, 2002; Kanwisher, McDermott, & Chun, 1997; Lavie, Ro, & Russell, 2003; Ro, Russell, & Lavie, 2001; Vuilleumier, Armony, Driver, & Dolan, 2001; Vuilleumier & Schwartz, 2001). It has been reported that the rapid processing of human faces is carried out efficiently and automatically even by infants in early stages of development (Hansen & Hansen, 1994). In terms of how fast the processes are carried out for emotional stimuli and faces, we consider that a phenomenon called repetition blindness may be useful for overcoming the difficulty in understanding the early processing of our visual system (Kanwisher, 1987).

Repetition blindness is defined as difficulty in detecting or reporting repeated items within a short array of stimuli compared to when they are all different (Kanwisher, 1987). The repetition blindness paradigm offers an opportunity to investigate the role of lexical and sublexical representations when stimuli are presented in rapid serial succession.
greater repetition blindness effect is observed when fewer distractors are placed between the two repeated targets. The length of the exposure rate for each stimulus also affects the size of this effect. This effect is observed most strongly when each item is presented for 83 to 180 msec (Coltheart & Langdon, 2003; Kanwisher, 1987; Park & Kanwisher, 1994). In addition, attention plays an important role in repetition blindness and the magnitude of repetition blindness can be somewhat attenuated when the participants are notified about the repetition beforehand. This decrease in magnitude of repetition blindness is only observed for those stimuli dimensions to which participants are attending. However, repetition blindness cannot be completely diminished or controlled (Kanwisher, 1991; Kanwisher & Driver, 1995).

To identify two identical stimuli successfully as two different instances in an array, one must be able to perceive each item individually. This process is crucial for the stimulus to reach one’s conscious level (Morris & Harris, 2004). The most readily accepted explanation for repetition blindness is called the token individuation hypothesis (Kanwisher, 1987). According to this hypothesis, in the early stages of visual processing, objects are captured preattentively and do not reach consciousness (“types”). It is only in the later stages of visual processing that objects are identified semantically within their spatial location and temporal order (“tokens”) (Kanwisher, 1991). Once individuation of the first target begins, for a limited amount of time, representation of an identical stimulus can be activated as a type but not individuated as a token. Thus, the occurrence of an identical second target within this interval would inhibit the individuating process and elicit repetition blindness. Furthermore, when representation of the first item is manipulated in perceptual and semantic intensity or length of exposure rate, it induces greater repetition blindness. This implies that the first target in an array plays a critical role in repetition blindness and individuation of the identical second target (Kanwisher, Kim, & Wickens, 1996).

Previous research have reported repetition blindness by using words, individual letters within words (Harris & Morris, 2000; Park & Kanwisher, 1994), uppercase and lowercase letters (Kanwisher, 1987), nonwords (Harris & Morris, 2004), colors (Kanwisher, 1991), pictures (Bavelier, Prasada, & Segui, 1994; Kanwisher, Yin, & Wojciulik, 1999), and pseudo-objects (Arnell & Jolicoeur, 1997) as repeated targets. Others have reported semantic repetition blindness with conceptual repetition of synonyms (MacKay & Miller, 1994), and conceptual repetition blindness using names of participants or other recognized names (Arnell, Shapiro, & Sorensen, 1999). Thus, while a lot of studies focused on the early stages of processes, only few studies have focused on the influences of emotional valence of the stimulus in repetition blindness.

In one study, emotionally negative words (such as death) and non-emotional words (such as ink) were used as stimuli shown in rapid serial visual presentation (Silvert, Navetuer, Honore, Sequeira, & Boucart, 2004). The repetition blindness effect was greater when the reported targets were emotionally negative compared to non-emotional words. However, by only using emotionally negative and non-emotional words, it is unclear whether the negative component of the stimulus or the emotional component associated with the stimulus induced the greater repetition blindness. In addition, as
several stages of processes are required in word recognition, stimuli such as faces that capture attention and that are easily detected in a short duration are better suited for focusing on the early process of repetition blindness. This hypothesis has not been tested previously using a repetition blindness paradigm.

In the present study, we investigated whether different types of emotional valence have distinct effects on repetition blindness using emotional faces and non-emotional stimuli. We used schematic faces as opposed to photographs, as different types of emotions can be expressed by minimal changes in features. Happy faces were emotionally positive stimuli, angry faces were emotionally negative stimuli, and scrambled faces (explained in detail later) were non-emotional stimuli. If distinct emotional valence is differently represented, the magnitude of the repetition blindness is expected to differ when happy and angry faces appeared as repeated targets. However, if it is the emotional component in general that induces strong representation and leads to greater repetition blindness, the magnitude of repetition blindness should be equivalent for the two emotional faces appearing as repeated targets.

METHODS

Participants. Twenty-three healthy volunteers (12 females and 11 males) from Keio University participated, being enrolled after giving written informed consent. Their mean age was 21.4 years. All participants had normal or correct-to-normal vision.

Apparatus. Stimuli were presented on a monitor 60 cm distant from the participants. The duration and the timing of the stimulus presentation were controlled by tachistoscope (IS-702, Iwatsu ISEL). Trials began when the experimenter pressed the start key on the computer keyboard. The participants responded by pressing prespecified keys connected to tachistoscope. During the experiment, key-press responses and reaction times were recorded on a computer, and the verbal responses were recorded by the experimenter.

Materials. Six types of schematic faces with emotional expression and three types of non-emotional stimuli were used. All stimuli were made up of four straight or curved lines inside a white circle, which was presented at the center of the display on a black background. Emotional faces were three different happy faces and three different angry faces. Non-emotional stimuli were three different scrambled faces composed with the same schematic components as the emotional faces.

Before the experiment, prior assessment was carried out. The participants who did not attend to the main part of the experiment were asked to rate each stimulus using a six-digit Likert scale, to specify whether the stimulus was recognized as a face using anchors of 1: Definitely recognized the stimulus as a face and 6: Could not at all recognize the stimulus as a face. For items recognized as faces, participants were also asked to rate whether the face bore positive or negative emotion in a similar manner using anchors of 1: Most positive and 6: Most negative. Based on the results of the prior assessment, nine stimuli were divided into three different stimulus types; happy face, angry face, and scrambled face. Mean scores for each stimulus type were analyzed by t-test. Analysis showed that scores for all stimulus groups were significantly different from one another: for happy face versus angry face ($t(11) = 18.52, p < .01$); happy face versus scrambled face ($t(11) = 7.57, p < .01$); angry face versus scrambled face ($t(11) = 8.11, p < .01$), indicating that the groups were distinctive.

In the main part of the experiment, stimuli were presented in rapid serial order at the center of the display, without any interval between each item. The experiment was divided into three blocks of 36 trials, 108 trials altogether, and in each array there were five stimuli. One half of the experiment was repeated trials and the other half was non-repeated trials, appearing in a random order within each block. The three blocks differed in exposure rates of each stimulus; 150 msec, 180 msec, and 250 msec. Six different sets of stimulus arrays were made for repeated trials: (1) Happy face targets versus angry face distractors, (2) happy face...
targets versus scrambled face distractors, (3) angry face targets versus happy face distractors, (4) angry face targets versus scrambled face distractors, (5) scrambled face targets versus happy face distractors, and (6) scrambled face targets versus angry face distractors. In all the repeated trials, targets either appeared in the first and third positions, in the second and the fourth positions, or in the third and the fifth positions of the array. Targets were always those previously assessed as most appropriate for each type of stimulus group. Non-repeated trials were constructed using the same stimuli as repeated trials, but the second target was replaced by a stimulus that differed from the first target or the distractor types.

Procedure. Participants were tested individually. They were seated before the display and the response keys. The participants were instructed to keep their eyes fixed at the center of the display during all trials, and perceive each stimulus holistically. Each trial began with a 500 msec presentation of six asterisks, followed by an array of stimuli without any interval (see Fig. 1). After the presentation was complete, six percentage marks were presented and then the display went blank. After having seen the whole array, participants pressed one key if any repetition was detected, and another key if not. When the key was pressed, the word answer? appeared on the display. If a repetition was detected, the participants answered the name of the stimulus (happy face, angry face, or other for scrambled faces). If no repetition was detected, they answered none. After making their decisions, they pressed any key to initiate the next trial.

RESULTS

Only trials with reaction times longer than 100 msec and within three standard deviations were analyzed. This lead to loss of less than 2% of the trials.

Repetition Blindness. The individual mean accuracy for repeated trials and non-repeated trials were submitted to an analysis of variance with trial type (repeated vs. non-repeated), and exposure rate (150 msec vs. 180 msec vs. 250 msec) as within-subject factors. Overall mean accuracy for both trial types are shown in Table 1. There was a main effect of the trial type ($F(1, 22) = 33.72, p < .001$). The mean accuracy of non-
repeated trials was higher than that of repeated trials, indicating repetition blindness. In addition, there was a main effect of the exposure rate \((F(2, 44) = 8.91, p < .001)\). Ryan’s multiple comparison analysis revealed that, while accuracy was higher for the 250 msec condition than for the 180 msec and 150 msec conditions \((p < .001\) and \(p = .018\), respectively), there was no difference between 180 msec and 150 msec conditions \((p = .089)\). Interaction was not significant \((p = .381)\).

Repeated Trials. The mean accuracy of the repeated trials are shown in Fig. 2. These results were submitted to an analysis of variance with target type (happy face vs. angry face vs. scrambled face), and exposure rate (150 msec vs. 180 msec vs. 250 msec) as within-subject factors. The target type main effect was significant \((F(2, 44) = 10.41, p < .001)\), indicating that the accuracy differed depending on the target faces. Ryan’s multiple comparison analysis revealed that the mean accuracy of the happy faces were higher than that of both angry and scrambled faces \((p < .001\) and \(p < .001\) respectively). However, there was no difference in mean accuracy between angry and scrambled faces \((p = .911)\). This result implies that less repetition blindness was associated with happy faces compared to the other two types of faces. In addition, there was a main effect of exposure rate \((F(2, 44) = 3.73, p = .032)\). Ryan’s multiple comparison analysis revealed that the mean accuracy of the 250 msec condition was higher than that of 150 msec condition \((p < .010)\), but there was no difference between 250 msec and 180 msec conditions.

<table>
<thead>
<tr>
<th>Trial type</th>
<th>150 msec</th>
<th>180 msec</th>
<th>250 msec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-repeated</td>
<td>0.58</td>
<td>0.70</td>
<td>0.74</td>
</tr>
<tr>
<td>Repeated</td>
<td>0.32</td>
<td>0.32</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Table 1. Overall Mean Accuracy for Detection of the Target in Nonrepeated and Repeated Condition.

Fig. 2. Mean accuracy for the target type and exposure rate conditions in repeated trials. Error bars represent the standard errors of mean.
conditions, and 180 msec and 150 msec conditions ($p = .078$ and $p = .389$, respectively).

The target type and exposure rate interaction was also significant ($F(4, 88) = 2.73$, $p = .034$). Post hoc analysis revealed that in the 150 msec and 180 msec conditions, the accuracy of the happy faces were higher than that of angry and scrambled faces (for 150 msec $p < .001$ and $p = .002$, respectively; for 180 msec $p = .038$ and $p = .028$, respectively). However, there was no significant difference between angry and scrambled faces (for 150 msec $p = .078$; for 180 msec $p = .912$). For the 250 msec condition, there was no significant difference between any of the target types. These results suggest that when the exposure rate is shorter than 180 msec, the participants identified the happy faces better than angry and scrambled faces.

Furthermore, when the angry faces were presented as repeated targets, it was revealed that the accuracy for the 250 msec and 180 msec conditions were higher than that of 150 msec condition ($p < .001$ and $p = .029$, respectively). However, such difference in accuracy depending on the exposure rate was not observed either in happy or scrambled faces. These results suggest that only the angry faces were susceptible to the exposure rate, and the accuracy dropped significantly when the exposure rate was very short.

**Non-Repeated Trials.** The mean accuracy for each target type and exposure rate of the non-repeated trials are shown in Table 2. These results were submitted to an analysis of variance with target type (happy face vs. angry face vs. scrambled face), and exposure rate (150 msec vs. 180 msec vs. 250 msec) as within-subject factors. The target type main effect was significant ($F(2, 44) = 6.22$, $p = .004$), indicating that the accuracy differed depending on the faces. Ryan’s multiple comparison analysis revealed that the mean accuracy of the happy and angry faces were higher than that of scrambled faces ($p = .002$ and $p = .014$ respectively). However, there was no difference in mean accuracy between happy and angry faces ($p = .422$). The exposure rate main effect was also significant ($F(2, 44) = 10.42$, $p < .001$), indicating that the accuracy differed depending on the exposure rates. Ryan’s multiple comparison analysis revealed that the mean accuracy of 180 msec and 250 msec conditions were higher than that of 150 msec condition ($p = .004$ and $p < .001$ respectively). However, there was no difference in mean accuracy between 180 msec and 250 msec conditions ($p = .168$). These results suggest that in the non-repeated trials, the accuracy was higher for the emotional faces than non-emotional stimuli, and generally, when the overall exposure rates were longer than 150 msec.

<table>
<thead>
<tr>
<th>Target type</th>
<th>150 msec</th>
<th>180 msec</th>
<th>250 msec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Happy face</td>
<td>0.64</td>
<td>0.74</td>
<td>0.82</td>
</tr>
<tr>
<td>Angry face</td>
<td>0.61</td>
<td>0.74</td>
<td>0.76</td>
</tr>
<tr>
<td>Scrambled face</td>
<td>0.51</td>
<td>0.63</td>
<td>0.69</td>
</tr>
</tbody>
</table>
DISCUSSION

In the present study, we investigated whether different types of emotional valence were associated with repetition blindness using emotional faces (happy faces, angry faces) and non-emotional stimuli (scramble faces). While there was no difference in mean accuracy between two types of emotional faces on non-repeated trials, accuracy was significantly lower for the angry faces compared to the happy faces on repeated trials, inducing greater repetition blindness.

These results have two important implications. One important implication was that the mean accuracy of non-repeated trials was significantly higher than that of repeated trials, suggesting that repetition blindness was inferred. When the same emotional stimulus was not repeated, each stimulus was correctly individuated. However, when the same stimulus intervened rapidly after the first target was presented, individuation of the second target became difficult, inducing greater repetition blindness; this repetition blindness was stronger when the angry faces were repeated as targets compared to the happy faces. A question remains regarding why the mean accuracy of the angry faces dropped dramatically when they were repeated, and not when the happy faces were repeated. If perceptual difficulty were involved in low accuracy of the repeated trials, results would have been equivalent for both emotional faces in non-repeated and repeated trials.

On whether repetition blindness is related to attention, a large body of evidence suggests emotionally negative or threatening stimuli elicits and holds attention more successfully than other types of emotional stimuli. This could be associated with an increase in emotional intensity of the repeated targets and extending the time required to individuate the first target; thereby, temporarily inhibiting assignment of the identical second target as a separate event. In a previous study, evaluation of emotionally negative components induced larger repetition blindness, which is consistent with the present results (Silvert et al., 2004).

However, it is worth noting that the magnitude of the repetition blindness for the scrambled faces was equivalent to that of angry faces. Thus, although the deficit in processing emotionally negative stimuli seems plausible, there needs an explanation for the low accuracy with scrambled faces.

A possible explanation for the strong repetition blindness and low accuracy in scrambled faces is that they were simply harder to recognize, compared to the happy and angry faces. For example, a previous study has shown that the intact faces and scrambled faces are processed in a different manner (Tanaka & Farah, 1993). In their experiment, the participants were asked to memorize intact and scrambled faces paired with male names. In the test phase, the participants were either asked to identify the isolated feature of the learnt faces (e.g., which is Bob’s nose?), or they were asked to identify the whole face that matched the given name (e.g., which is Bob?). Results showed that the accuracy was higher for the whole face than isolated part condition for the intact faces, but the accuracy for the two conditions were equivalent for the scrambled faces. Furthermore, performance for the whole face was superior to that of the scrambled faces. These results suggest that a
portion of a face is better recognized when presented as a face, than when presented as a portion of something other than a face. This is because faces are processed in holistic manner to a greater degree compared to other form of objects (Palmer, 1977; Tanaka & Farah, 1993; Schubo, Gendolla, Meinecke, & Abele, 2006). Thus, the ease of grouping the facial parts play an important role in face recognition. Other research has shown that the advantage of negative emotional face is only observed when the face is presented as a whole face (Schubo et al., 2006). And this emotional advantage is eliminated when the features alone are presented without the face contour. This result also suggests the importance of the unity and holistic processing in face recognition.

In the present study, all types of stimulus were composed with the same schematic components. In happy and angry faces, the components were positioned so that they resembled faces. In contrast, in scrambled faces, the components were positioned randomly so that they did not resemble faces. This might have caused the difficulty in recognizing scrambled faces. This is also supported by the low accuracy of scrambled faces in non-repeated trials, compared to the emotional faces. Thus, while greater repetition blindness was observed with angry faces due to an increase in emotional intensity, repetition blindness observed with scrambled faces suggest that it was due to difficulty in simply recognizing the object.

Another important implication in our study was that this emotionally negative effect on the magnitude of repetition blindness was strongly observed in the short exposure rate condition. That is, when the angry faces were repeated, the accuracy dropped dramatically in the 150 msec condition. However, when the happy and scrambled faces were repeated, accuracy tended to stay constant regardless of these exposure rates. This inconsistency among exposure rates for angry faces might be associated with their strong attentional capturing power, as highly arousing emotionally negative stimuli are said to have an exceptionally strong effect on psychological processes (Ohman, Flykt, & Esteves, 2001; Ohman, Lundqvist, & Esteves, 2001). Increased sensitivity to the short exposure rate with the angry faces can be interpreted as enhanced emotional alertness elicited by the increased intensity of the emotional processes. This can also be understood through an evolutionary point of view (LeDoux, 2001). Taken together with the defense systems being evolved as an alert to danger, angry faces induced strong attentional capture. This lead to greater emotional repetition blindness, typically when they were presented for a very short time (Ohman & Mineka, 2001).

In summary, the present study suggests that the repetition blindness effect may vary in magnitude depending on the different types of emotional valence. This effect becomes clear when angry faces are presented as the repeated targets, but only when the exposure rate was short. The increased sensitivity to the shortest exposure rate was only observed for the angry faces, which is probably due to an enhanced emotional alertness elicited by the increased intensity of emotional processes.
REFERENCES


*(Manuscript received 23 August, 2010; Revision accepted 12 April, 2012)*