The effect of anxiety on attentional capture by negative emotion

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Abstract

Previous studies (MacLeod, Mathews & Tata, 1986 ; Mogg and Bradley, 2002) suggested that a small dot could be detected faster when it followed a threatening stimulus than when it followed neutral or positive stimuli. These studies suggested that participants automatically allocate their attention to the spatial location of fear-related stimuli. Some of these studies suggested that there is a visual field difference in the effect of threatening stimuli (Fox, 2002) . However, there were few studies that compared within field and between-field effect of attentional capture since most of them employed only two locations (one for each visual field), thus confounding the validity (which is determined by the relationship between threatening stimulus and probe) and the visual field of probe. We investigated this issues and the effect of participants' anxiety level on the degree of attentional capture.

Key Words : attentional capture, threat, anxiety

Introduction

Previous studies (LeDoux, 1996; Öhman, Flykt & Esteves, 2001) have shown that threatening stimuli can capture attention automatically, perhaps because of its potential threat to the organism. These studies demonstrated that the valence of threat-related stimuli such as angry face and dangerous animals (e.g., snakes and spiders) were processed automatically and that they could facilitate performance to subsequent probe stimuli. Thus, they could be detected faster when presented at the location of threatening stimulus than then they appeared at the location of either positive or neutral stimulus (Bradley, Mogg, Falla & Hamilton, 1998; Öhman et al., 2001).

These studies have given support to the proposition that fear-related stimuli can automatically capture attention. An argument based on evolutionary perspective maintains that this bias toward threatening stimuli is a result of adaptation to environmental dangers, so that they are detected immediately to make quick coping responses toward them (LeDoux, 1996; Öhman, 1986; Öhman et al., 2001; Öhman, 2000).

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There have been several experimental paradigms for the study of automatic attentional control by emotion. One such paradigm is probe task (MacLeod, Mathews & Tata, 1986; Bradley et al., 1998), in which people are required to detect or discriminate a probe that followed emotional stimuli. Response latencies for detecting or discriminating it is used as an index of automatic attentional deployment (i.e., attentional capture) toward it.

For example, in a previous study Mogg and Bradley (2002) used the probe task and found that the reaction times (RTs) to a small dot (i.e., probe) that followed a threatening stimulus were faster than those after neutral or positive stimulus, suggesting that attention is automatically controlled by the emotional significance of the stimulus or its affective valence.

As mentioned above, many previous studies that used the probe task found that detection or discrimination performance to a probe that appeared at the location of threatening stimuli was facilitated relative to neural or positive stimuli. In these studies, usually a pair of pictures (i.e., a threatening and a neutral pictures) were presented bilaterally with one picture (either threatening stimuli or neutral stimuli) being in the left visual field and the other in the right visual field. Attentional capture was inferred by the fact that RTs in the condition where both stimuli appeared in the same location (following the convention of spatial attention literature, this condition was designated valid, while the condition in which two stimuli appeared in different locations was called invalid) were faster than when they appeared in opposite visual fields. Therefore, these two conditions were not identical in the visual fields in which two stimuli (i.e., threatening picture and probe) appeared. In the valid condition they were in the same visual field, thus presumably they were sent to the same hemisphere. However, in the invalid condition they appeared in different visual fields, thus being sent to different hemispheres. Thus, it is not clear whether the facilitation was simply due to the fact that the two stimuli appeared in the same visual field or location and thus were processed in the same hemisphere or it was a true attentional capture effect. To clarify this confound, we presented probe and threatening stimuli at one of four locations (in the four quadrants), making it possible to present both threatening stimulus and probe in the same visual field even in a invalid condition.

In addition, many previous studies showed the effect of anxiety on attentional capture by threatening stimuli. In fact, there have been many studies investigating attentional capture effect of negative emotion, especially angry facial expression, which found that individual's anxiety level was related to the attentional control potency of negative emotion (Eysenck, 1988; Macleod et al., 1986; Mogg & Bradley, 1999; Öhman, 1996). In the present study, we also explored the effect of anxiety on the effect of automatic attentional capture by angry face.

Method

Participants

30 subjects ranging in age from 19 to 20 years with normal or corrected-to-normal vision were recruited from Shokei Gakuin University and they participated in this study in 2006.

Materials

We used angry face as evolutionarily relevant emotional stimulus with neutral face as non-emotional stimulus: These face icons were taken from the Windows font of Windings. Mask stimulus was a wheel like figure, which was found in the Window font of Windings2. An IBM-PC compatible computer was used for presentation of stimuli and collection of responses. The experiment was controlled by a program running on the Windows using Direct-X routines. The size of each face icons and mask stimuli were 96 dots X 96 dots (2° × 2°). Each stimulus was presented at one of the four corner positions of an imaginary square with a fixation mark at its center. The center-to-center distance of the two corners were 3° in visual angle.

Participants were seated about 57cm from a 17-inch liquid crystal monitor used for stimulus presentation. The target (called probe here) to be responded to was either an upward arrow or a downward arrow (“∧ or ∨”). The size of the target was 0.3° in visual angle.

Following the convention of spatial attention research the angry face was called a "cue". The probe was designated as Valid when it was presented at the location of the cue, while it was Invalid when presented at some other location than the place where the cue was presented, that is, at a location of neutral face. There were three invalid conditions: Invalid-SM, Invalid-OPST, and Invalid-DGNL. It was designated Invalid-SM when the probe occurred in the same visual field but at a different corner of that field as the angry face icon. When it was presented in the visual field opposite to the angry face icon, but in the same row with the latter (i.e., when angry face icon was shown in the upper row of one visual field probe also appeared in the upper row of the other visual field or when it was shown in the lower row prove was also in the lower row), it was designated Invalid-OPST. And in Invalid-DGNL condition the probe appeared at the location diagonal to the cue in the opposite visual field.

Procedure

The participants were asked to indicate the direction of the arrow (“∧ or ∨”) presented after the offset of face icons, by pressing one of two keys. The target was presented at one of four locations where face icons were presented. Participants were brought into a testing room and instructed to indicate the direction of the arrow that was presented immediately after the termination of mask stimuli.

After having performed a short practice session of 10 trials, they were asked to

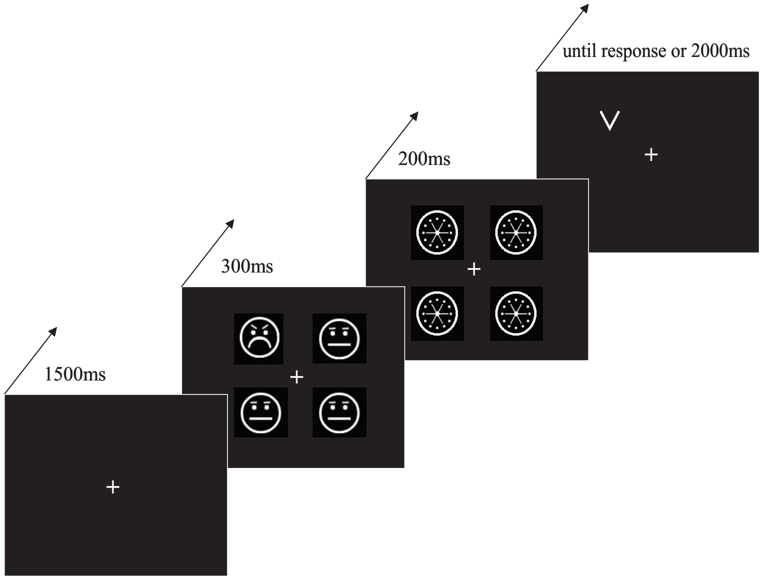

Figure 1. Stimulus presentation sequence of a trial.

participate in the test session of 192 trials. The order of the conditions was randomized for each participant. The sequence of events within each trial was as follows (see Figure 1): a fixation mark (+) was presented at the center of the screen and remained there throughout the trial. One thousand five hundred msec after the presentation of the fixation mark the face icons appeared for 300ms at the four corner of an imaginary square. The four face icons consisted of one angry and three neutral faces. After 300 msec the four identical mask icons replaced the face icons, which were displayed for 200 msec. Immediately after the offset of these mask stimuli, an arrow (either "∧ or ∨") was presented at one of the four locations of face icons, which was displayed until response or for 2000 ms when there was no response.

The participants were instructed to respond to the arrow as quickly and as accurately as possible. The left index finger pressed Z key, which corresponded to the upper arrow("∧"), while the right index finger was assigned to / key for the downward arrow ("∨").

The experiment consisted of 2 blocks of 192 trials each. The 192 trials were composed of a factorial combinations of the following conditions: 4 locations of the probe (the upper right, the lower right, the upper left, the lower left) × 4 validity conditions (valid, invalid-SM, invalid-OPST, invalid-DGNL) × 12 (the number of repetitions). Immediately after the experiment, each subjects completed the SATI anxiety scale.

Classification by anxiety

The participants were median-split into high-anxiety and low-anxiety groups according to their SATI trait or state score. Thus 15 participants belonged to high SATI trait-anxiety or state-anxiety group and the remaining 15 participants belonged to the low anxiety group of respective criterion. To test individual difference in anxiety on the degree of attentional control by angry face two-way ANOVAs with 4 (location of the probe ("∧ or ∨") : the upper right, the lower right, the upper left, the lower left) × 4 (validity: valid, invalid-SM, invalid-OPST, invalid-DGNL) factorial design were applied to the average RTs of each anxiety group formed by each participant's trait or state anxiety score.

Results

RTs greater than 1000 ms or less than 150 ms were excluded from data analysis as outliers. Two-way ANOVA with four levels of validity (valid, invalid-SM, invalid-OPST, and invalid-DGNL) and four levels of cue location (upper right, lower right, upper left, and lower left) was conducted to test the general effects of cue location and validity. It revealed no significant main effect ($F\ (3, 87) = 1.24$ for validity and $F\ (3, 87) = 0.85$ for cue location). However, there was a significant interaction between validity and cue location ($F\ (9, 267) = 5.38$, $p < .001$), suggesting that the attentional capture by the angry face was modulated by the quadrant in which it appeared (see Figure 2 on this interaction).

To clarify the above point, RT performance of each invalid condition was individually contrasted with that of the corresponding valid condition for each quadrant, separately. They revealed significant facilitation for the valid condition relative to some of the corresponding invalid conditions. For the upper left quadrant valid RT was faster than both invalid-SM ($F\ (1, 29) = 10.32$, $p < .01$) and invalid-OPST RTs ($F\ (1, 29) = 5.03$, $p < .05$), while there was no significant difference between Valid and Invalid-DGNL RTs ($F\ (1, 29) = 1.36$). Similar RT facilitation pattern was found for the lower right quadrant with marginally significant Valid vs. Invalid-SM and significant Valid vs. Invalid-OPST comparisons ($F\ (1, 29) = 3.44$, $p <.1$; $F\ (1, 29) = 10.97$, $p < .01$, respectively) with no significant difference in performance between Valid and Invalid-DGNL comparison ($F\ (1/29) = 0.28$). Thus, in these two quadrants it may be said that attention was captured by the angry face both within and between visual fields. In other quadrants, there was little statistical indication of attentional capture. Only exception was the contrast between Valid vs. Invalid-DGNL for the upper left quadrant ($F\ (1/29) = 6.74$, $p < .01$), indicating faster RT for Valid relative to Invalid-DGNL conditions. For the lower left quadrant, although both Valid vs. Invalid-SM and Valid vs. Invalid-OPST contrasts ($F\ (1, 29) = 9.64$, $p < .01$; $F\ (1, 29) = 6.23$, $p < 05$, respectively) were statistically significant, it was due to slower RT of the valid condition relative to the invalid conditions rather than the expected RT facilitation, implying attentional aversion from the angry face.

Both trait and state anxiety of the participants had little effects on the attention capture by the angry face. The only significant result was the interaction between cue location and validity ($F\ (9, 126) = 3.17$, $p < .005$) for high state anxiety group (Figure2, Table 1). Therefore, this point was dropped from further discussions.

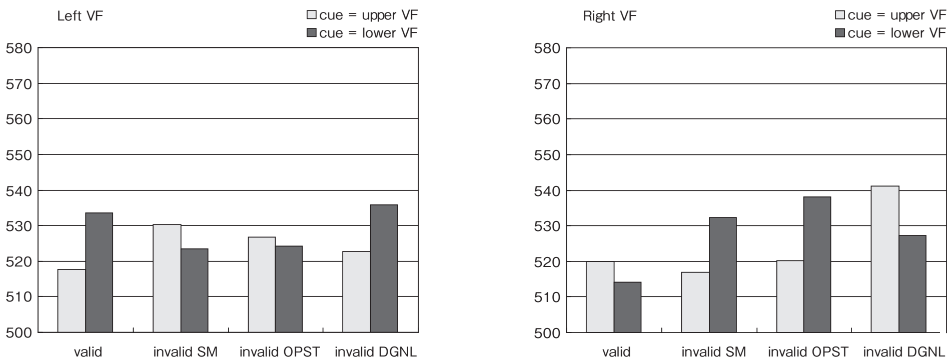

Figure 2. Mean Reaction Times for the Validity conditions (upper figure: left visual field, lower figure: right visual field).

Table 1. Effect of state and trait anxiety. Mean RTs and their Standard Deviations were shown separately for the location of the probe and validity conditions.

Location of Target Stimuli and validity	Reaction Time			
	state		trait	
	M	*SD*	*M*	*SD*
Upper Left				
valid	517.62	73.42	536.46	61.41
invalid SM	530.32	75.78	552.95	71.58
invalid OPST	526.69	75.87	547.52	66.83
invalid DGNL	522.64	82.04	538.23	80.55
Lower Left				
valid	533.64	75.40	555.73	73.24
invalid SM	523.58	84.90	530.74	75.81
invalid OPST	524.21	93.21	541.30	79.61
invalid DGNL	535.71	102.17	555.88	72.77
Upper Right				
valid	520.02	71.97	545.02	61.47
invalid SM	516.79	88.91	547.07	82.27
invalid OPST	520.16	60.32	536.71	54.87
invalid DGNL	541.03	96.91	564.15	89.65
Lower Right				
valid	514.01	81.58	544.93	77.59
invalid SM	532.29	90.64	560.53	80.18
invalid OPST	538.13	93.90	561.60	73.53
invalid DGNL	527.37	94.52	546.71	83.63

Discussion

In this study, we investigated whether attentional capture by an angry face could be found when both probe and emotional stimulus were presented within the same visual field. In our previous study (Miyazawa and Iwasaki), we found a visual field difference in that threatening pictures captured attention only when they were presented in the right visual field. In that study, like many other previous studies that explored this issue of attentional capture by negatively valenced stimuli, probe and emotional pictures were presented in different visual fields when the validity condition was invalid but they appeared in the same visual field when it was valid. Therefore, the two validity conditions were not identical in the visual fields in which two stimuli (i.e., threatening picture and probe) appeared. In this study, two invalid conditions were set to clarify the visual field and validity confound in our previous study as well as most of the previous studies by presenting one angry and three neutral faces. Thus, probe could be invalid both within the same visual field (Invalid-SM condition) and across the visual fields (Invalid-OPST condition). The results demonstrated that there was a rather complex interaction involving four quadrants of visual fields depending on the locations of angry face and the probe. Thus, when the angry face was presented in either upper-left or lower right visual field it facilitated probe discrimination performance for the valid condition relative to the invalid conditions, suggesting attentional capture, while it had the reverse effect of slowing when it was presented in the upper left visual field, suggesting attentional aversion by the threatening stimulus.

Another point investigated in this study was whether the natural threat stimulus like angry face had its effect on the automatic control of attention irrespective of anxiety level of participants or it is modulated by their anxiety level. In this respect, there have been many previous studies that demonstrated the effect of participant's anxiety on the degree of attentional capture with higher anxiety leading to larger effect (Eysenck, 1988; Macleod et al., 1986; Mogg & Bradley, 1999; Öhman, 1996). However, in this study, both trait and state anxiety had little effect on the performance. Only exception was the interaction that was found between visual field and validity when the participants were classified by their state anxiety scores, which was difficult to interpret. Perhaps this may be accounted for either by low negative valence of the angry face used in the present study or the type of anxiety relevant for the angry face's effect on attention, that is, classifying participants by their degree of social phobia rather than by general anxiety might have produced different results in the degree of attentional capture by angry face.

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