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Don't look there: the impact of facial expression on location negative priming

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Abstract

This study used the location negative priming (NP) paradigm and the recording of event related potentials (ERPs) to examine the mechanism of the impact of emotional stimulus on subsequent spatial attentional processing. The results showed relative to the happy and neutral condition, a significant behavioural NP effect, as well as decreased N2, increased N2pc and P3 amplitudes for NP condition were found selectively in the fearful prime distractor condition. These findings suggest that the effect of fearful stimulus on location NP may be related to early inhibition processing. Larger P3 amplitudes may reflect the use of increased cognitive resources when one is necessary for overcoming the tendency to avoid viewing the position where a fearful stimulus has recently been seen.

Keywords

facial expression; location negative priming; selective attention

Introduction

Strong attentional biases to emotional, particularly threatening stimuli have indeed been demonstrated in many studies [1]. Researchers have also been interested in examining what occurs after attentional bias has been established. Mogg and Bradley [2] posited that the attentional bias to fearful stimuli were not expected to be maintained over time. Öhman and Mineka [3] suggested that when we feel fear, we are apt to escape the situation rather than linger to evaluate in-depth the actual dangers involved with it. Accordingly, after an initial attentional bias toward threatening stimulus, it would seem prudent to avoid them.

Neural correlates of attentional bias to negative stimuli have been widely reported [4]. However, data elucidating the mechanism mediating the attentional avoidance of negative stimuli remain scarce. An eye movement study showed that the spider anxious individuals avoided spiders when their direction of gaze was assessed 2000–3000 ms after stimulus

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onset [5]. A visual probe study found individuals with high levels of blood-injury fear showed avoidance of the threatening images at 1500 ms post-stimulus onset [6]. However, the few studies on the avoidance of negative stimuli have only examined neuropaths [2, 5–8]. There is a dearth of reports that have examined cognitive and neural mechanisms of the avoidance of negative stimuli in healthy people and the influence of the avoidance of threatening stimuli on spatial processing is unclear. Against this background, the aims of the present study were to use the location negative priming (NP) paradigm and ERP measures to explore the neural correlates of the avoidance of fearful stimuli, and to investigate how emotional distractor influences subsequent spatial processing.

Location NP paradigm is an established tool for the investigation of location selective attention and location NP effect refers specifically to the slowing of a response to a previous distractor position when that location becomes the target position in a subsequent trial [9,10]. There are two major theoretical approaches to explain the NP phenomenon. One, the distractor inhibition model, assumes that access to the representation which is inhibited in the prime phase slows down the responding in the probe phase [10]. In accordance with the view that the prefrontal cortex is the locus of central inhibition and control processes, some studies have indeed found frontally located ERP components (e.g., N2) in the location NP task [9,11]. Ruge and Naumann [12] have found a N2pc component with an enhanced amplitude (posterior contralateral) for NP condition as compared to control. This component has often been used to study the deployment of attention in visual search task and is assumed to reflect spatially selective attentional processing [9,12,13]. A few studies have also shown a larger P3 for NP condition and interpreted it as indicating that more attentional resources are required for the inhibition processing [11,14]. Alternatively, the episodic retrieval model, argues that NP results from the retrieval of the prime episode [15]. The conflict between the do-not-respond information to the prime distractor and the requirement to respond to the same stimulus in the probe phase leads to the NP effect. According to this model, reduced amplitude of late ERP component (e.g., P3) for NP condition should be found because they reflected perceived prime-probe similarity [16,17]. With regard to the ERP results of the location priming experiments, early components for NP condition have been found in all studies [11,12, 18,19], which means inhibition processing plays an important role in this task. Based on the previous studies [11,12,18,20], we hypothesize that there will be a significant NP effect when fearful faces are used as the prime distractors, due to the avoidance of the position where fearful related stimuli were previously presented. We further hypothesize that there will be some early activation correlates (eg, N2 and N2pc) and a late positive potential for the NP condition, relative to the control condition, especially for the fearful prime distractors condition.

Methods

Participants

Sixteen right handed female undergraduates (mean age: 21, range: 18–24) from the Southwest University took part in this study. None of them had prior neurological/psychiatric history or take medication. Informed consent was obtained from all subjects.

Stimuli and experimental procedure

120 fearful, happy and neutral pictures selected from the standard Chinese Facial Affective Picture System [21] were employed as prime distractors. Each type of expression included 40 pictures (20 males, 20 females). Each picture had been assessed for its valence and arousal on a 9-point scale with a large sample of Chinese subjects in a previous survey. The three groups of pictures differed significantly in valence from one another, $F(2, 119) = 406.16$, $p < 0.001$ ($M \pm SD$: fearful: 2.73 ± 0.44 , happy: 6.27 ± 0.75 , neutral: 4.35 ± 0.43),

but the arousal of fearful and happy pictures were similar ($p = 0.508$) which differed from neutral pictures, $p < 0.001$ (fearful: 6.31 ± 1.22 , happy: 6.16 ± 1.05 , neutral: 3.72 ± 0.67). 20 upright house pictures were employed as prime targets, probe targets and probe distractors. All pictures were matched in terms of luminance and size. Every picture was outlined by a red or green border (visual angle was $3.29^\circ \times 2.79^\circ$). The target and distractor were presented in two out of the four locations around the cross in the centre of the screen (see Figure 1). The up-down, left-right visual field was counterbalanced between trials (visual angle was $6.48^\circ \times 7.88^\circ$).

The experiment was conducted in a dimly lit, sound-proof room. Subjects were seated on a comfortable chair with their eyes approximately 80 cm from a 17-in computer screen. Each trial was composed of two successive phases: prime and probe (Figure 1). In both phases, subjects were required to ignore the distractor outlined by green (red) border and press one of four buttons (left hand: button D, C; right hand: button K, M) corresponding to the position of the target outlined by red (green) border as quickly as possible and to avoid making errors. The colours of targets and distractors were counterbalanced between subjects. A trial began with the presentation of the prime, which was displayed on the screen until a response was made. After a response-stimulus interval (RSI) of 1200 ms, the probe display was presented and remained on the screen until a response was made. The inter-trial interval was chosen randomly in the range of 1300–1700 ms. E-Prime software was used for the stimulus presentation and data acquisition (Psychology Software Tools, Inc. Pittsburgh, USA).

20 practice trials were conducted prior to the main experiment. The main experiment included three emotional blocks. Each block presented one kind of facial pictures as the prime distractors. One block is composed of 200 trials: besides 80 NP trials and 80 control trials (In the NP trials, the probe target appeared at the position where the face distractor was previously presented; In the control trials, locations of targets and distractors were not repeated from prime to probe), 40 filler trials were conducted to prevent subjects using the response strategy (In these trials, location of prime target was same as the location of probe target or facial pictures were employed as probe targets). The sequence of trials in each block was random. Subjects could take a short break after every 50 trials and were asked to take a longer break (at least 8 minutes) between blocks to impair the implicit emotional effect of the previous block. The sequence of three blocks was counterbalanced between subjects.

Event-related potential recordings and data analysis

The electroencephalogram (EEG) was recorded from 64 scalp sites using tin electrodes mounted in an elastic cap (Brain Products, Brain Products GmbH, Munich, Germany). The EEG and EOG were amplified using a 0.016–100 Hz bandpass and continuously sampled at 500 Hz. All inter-electrode impedance was maintained below 5 K Ω . All the EEG data were digitally filtered with a 30 Hz lowpass filter for off-line analysis. Trials with EOG artefacts and other artefacts (peak-to-peak deflection exceeding $\pm 80 \mu\text{V}$) were excluded. ERP waveforms were time-locked to the onset of the probes and the average epoch was 1100 ms, including a 100 ms pre-stimulus baseline. Only epochs accompanying correct responses were considered.

According to the hypothesis, the average amplitudes of N2 (250 – 320 ms), P3 (320 – 420 ms) and N2pc (230 – 290 ms) were computed. The time window for each component was chosen on the basis of visual inspections. Six frontal sites (F3, Fz, F4, FC3, FCz, and FC4) were chosen for the analysis of N2, eighteen sites (F3, Fz, F4, FC3, FCz, FC4, C3, Cz, C4, CP3, CPz, CP4, P3, Pz, P4, PO7, POz and PO8) were chosen for the analysis of P3 and the two pooled electrode pairs O1-2, and PO7-8 were chosen for the analysis of N2pc. The

N2pc was computed between electrical activity contralateral minus ipsilateral to the target and then were averaged across hands with the Brain Vision Analyzer software:

$$N2pc = [\text{Average (right electrode - left electrode)}_{\text{target left}} + \text{Average (left electrode - right electrode)}_{\text{target right}}]/2$$

Amplitudes of each component were measured by a three-way repeated-measures analysis of variance (ANOVA) of Emotional block (fearful, happy and neutral) $\times$ priming condition (NP and control) $\times$ Electrode sites. The Greenhouse-Geisser epsilon correction was applied to adjust the degrees of freedom of the F-ratios.

Results

Accuracy values (ACC) were high in all conditions (all > 0.98) and there were no significant differences between conditions (all $p > 0.05$). So only the mean response time (RT) between 150 and 1200ms of the probes from trials with correct responses were taken into account (Table 1). The repeated measure ANOVA of Emotional block $\times$ priming condition revealed that neither emotional block ($F(2, 30) = 0.30$, $p = 0.68$) nor prime condition ($F(1, 15) = 0.05$, $p = 0.83$) had a significant main effect on RT. However, there was a significant emotional block $\times$ prime condition interaction ($F(2, 30) = 3.87$, $p = 0.04$). Post-hoc tests showed that RT in the NP condition was longer than RT in the control condition in the fearful block only ($p = 0.007$). The mean RTs for the NP and control conditions in happy ($p = 0.26$) and neutral ($p = 0.998$) blocks did not differ significantly from one another.

For the N2, the three-way ANOVA established a significant emotional block $\times$ priming condition interaction ($F(2, 30) = 4.22$, $p = 0.027$), though neither emotional block ($F(2, 30) = 1.68$, $p = 0.21$) nor prime condition ($F(1, 15) = 3.29$, $p = 0.09$) had a significant main effect (Figure 2). Post-hoc tests showed that when the fearful faces were used as the prime distractors, the average amplitudes of N2 in the control condition ($-0.76 \pm 0.87 \mu\text{V}$) was smaller than the N2 in the NP condition ($0.92 \pm 0.65 \mu\text{V}$, $p = 0.004$). However, N2 in the NP and control condition did not differ significantly from each other in neutral ($p = 0.397$) and happy ($p = 0.973$) blocks.

Figure 3 illustrates the N2pc for the NP and control conditions in three emotional blocks. The NP condition compared to control was associated with enhanced N2pc amplitudes in fearful block indicating a stronger signal deflection contralateral to the target location. The ANOVA revealed a significant block $\times$ priming condition interaction ($F(2, 30) = 6.07$, $p = 0.008$), though neither emotional block ($F(2, 30) = 1.82$, $p = 0.183$) nor prime condition ($F(1, 15) = 0.13$, $p = 0.727$) had a significant main effect. Post-hoc tests showed that when fearful faces were used as the prime distractors, the N2pc for the NP condition ($-0.83 \pm 0.40 \mu\text{V}$) was more negative than the N2pc for the control condition ($-0.13 \pm 0.32 \mu\text{V}$, $p = 0.009$). Average N2pc amplitudes in the NP and control condition did not differ significantly from each other in neutral ($p = 0.43$) and happy ($p = 0.38$) blocks.

For the P3, the three-way ANOVA established a significant block $\times$ priming condition interaction ($F(2, 30) = 4.88$, $p = 0.015$), though neither emotional block ($F(2, 30) = 0.58$, $p = 0.565$) nor prime condition ($F(1, 15) = 3.66$, $p = 0.075$) had a significant main effect (Figure 2). Post-hoc tests showed that when fearful faces were used as the prime distractors, the NP condition ($5.22 \pm 0.70 \mu\text{V}$) elicited larger P3 than the control condition ($3.40 \pm 0.78 \mu\text{V}$, $p = 0.006$). Average P3 amplitudes in the NP and control condition did not differ significantly from each other in neutral ($p = 0.57$) and happy ($p = 0.38$) blocks.

Discussion

The present study demonstrated a behavioural NP effect of fearful prime distractors in the fearful condition, which confirm the hypothesis that avoidance of viewing a location where a fearful stimulus was presented previously leads to a location NP effect. However, the NP effect in happy and neutral conditions was disappeared. Different from the neutral stimuli (e.g., digits, symbols) used in previously study[9,11,12], substantial evidence suggests faces could capture attention even when they are task-irrelevant [1]. The bias to facial pictures might be the course of the failed inhibition process and the eliminated NP effect for neutral faces in the present study. People are biased to attend to faces and will be in an approach-oriented anticipatory state following the happy expression [4]. In real world settings, a fear expression is a cue that an impending threat is present in the environment, while a happy expression represents a situation where a reward could be expected. 'Vigilant-avoidant' processing is thought to be activated under conditions of impending threat, whereas an approach tendency is expected under circumstances that may lead to a reward [4, 22]. Consistent with this theory, in the present study, avoidance of fearful faces may have accounted for the NP effect while a tendency to approach happy faces may have eliminated the NP effect.

Consistent with the behavioural results, the N2 we found was reduced in the NP condition relative to the control condition only in the fearful block. This reduced N2 may be related to the subjects' reduced tendency to attend to the location where a distractor presented previously. Interestingly, smaller N2 amplitudes being elicited in the NP condition, as reported here, are incongruent with data from overt negative priming and inhibition studies [9,12]. In those studies, subjects were usually required to evaluate and categorize a simple stimulus, such as a digit or letter. Inhibition processing related to distractors has been well established [9,12,17]. In contrast, our experiment examined an implicit effect of emotional stimuli on spatial processing. Given that emotional information draws attentional resources away from inhibition processing, the subjects had to inhibit emotional processing in order to accomplish the task, thereby leading to an inverted N2. These findings are consistent with Yu et al.'s [23] study and a previous study in our laboratory [24] in which N2 was found to be smaller for emotional conditions than for neutral condition. Thus, in the present experiment, the smaller N2 in the NP condition may be a reflection of individuals controlling and shifting their attention away from the position where threatening pictures had been presented previously.

Compared to N2, the N2pc component is a more reliable index of visual-spatial attention and is assumed to emerge through a biased competition between target and distractor positions with target location enhancement and distractor location suppression [9,25]. Consistent with the previous finding [12], we have found the N2pc effect was affected by the priming manipulation and emotion, which reflected the deployment of attention to a previously ignored location and supported the hypothesis of distractor inhibition model. The N2pc effect between NP condition and control condition was significant in the fearful distractor block only. Eimer [13] have found that task-irrelevant fearful faces can elicit an N2pc component and proposed that fearful stimulus can bias the spatial distribution of attention even when attention is narrowly focused. Consistent with their finding, the present study demonstrated that when the RSI was 1200ms, the fearful distractor could affect the subsequent spatial attention distribution which resulted in the significant NP effect in the fearful block.

We found increased P3 when the location of a house picture was negatively primed by a fearful face. Researchers [18] have reported an increase in P3 amplitude in identity NP task and interpreted it as an object repetition effect. However, in the present study, only locations

were repetitive and the object identities differed between the primes and probes. Therefore, it is unlikely that the increased P3 amplitude reported herein can be attributed to repetition. Alternatively, P3 amplitude has been suggested to reflect the amount of attentional resources that have been allocated to a task. Gibbons [11] argued that increased P3 amplitudes could be an index of effortful processing of the probe display and hence may reflect the need for additional resources when a probe target is being actively inhibited. Thus, the NP effect of this study is thought to reflect temporarily impaired access to the brain's representation of the prime distractors. This impaired access should correspond to more effortful stimulus processing, leading to a larger P3 in the fearful NP condition.

Conclusion

We have provided preliminary electrophysiological evidence of the impact of emotional distractors on the subsequent spatial processing. A significant location NP effect, as well as reduced N2, increased N2pc and P3 components for NP condition, were found selectively in the fearful prime distractors block. These findings suggest that the effect of a fearful stimulus on location NP may be related to early inhibition processing and increased cognitive resources, as indexed by P3, were needed for overcoming the tendency to avoid the position where fearful stimulus has recently been displayed.

Acknowledgments

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Fig.1.

Overview of the task paradigm. This example shows the NP trial with a happy face as the distractor. The probe target was presented in the position where the face prime distractor was previously presented.

Fig.2. Grand-averaged ERPs for the three emotional blocks (left = happy; middle = fearful; right = neutral) and the two priming conditions (control = dashed line; negative priming = solid line) at the Fz and Pz electrodes.

Fig.3.

Event-related lateralizations (ERLs) for the three emotional blocks (left = happy; middle = fearful; right = neutral) and the two priming conditions (control = dashed line; negative priming = solid line) at the O1-2 electrode.

Table 1RT (ms) and ACC in each emotion block and priming condition (mean $\pm$ SD)

	Emotional block	NP	Control	Significance (<i>p</i>)
RT	Happy	544.40 $\pm$ 97.44	549.41 $\pm$ 111.84	0.255
	Fearful	540.93 $\pm$ 70.84	534.17 $\pm$ 72.47	0.007
	Neutral	547.00 $\pm$ 75.38	546.99 $\pm$ 85.73	0.998
ACC	Happy	0.99 $\pm$ 0.01	0.99 $\pm$ 0.01	1.000
	Fearful	0.99 $\pm$ 0.02	0.99 $\pm$ 0.02	0.900
	Neutral	0.98 $\pm$ 0.01	0.99 $\pm$ 0.01	1.000