

Attention shortage resistance of negative stimuli in an implicit emotional task

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Abstract

Considerable evidence from behavioral studies has indicated that people tend to pay attention to negative stimuli preferentially. The attentional bias can occur rapidly and automatically. In the current study, a ‘cue-target’ paradigm was utilized to manipulate the attention allocation. Seventeen healthy undergraduates participated in the experiment. The stimuli were emotional pictures (positive, neutral and negative), which were upper and lower adjacent patchworks of a normal scene and its inverted copy. The subjects should judge whether the normal scene (compared with the inverted scene) was located in the upper or lower part of the whole patchwork. We used this implicit emotional task to avoid the task relevance effect. It was found that the amplitude of P2 waves was enlarged by the negative pictures and there was a significant interaction between the cue effect and the emotional valence. We can conclude that the negative information exerts an attentional bias effect in the emotional perception, and that the negative contents suffer less in the insufficient attention condition compared with the positive and the neutral conditions.

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Considerable evidence shows that there exists a negativity bias in emotion information processing. Compared with positive and neutral stimuli, people tend to pay more attention to those negative contents. Behavioral studies have provided lots of evidence on this issue. In a visual searching task, Hansen and Hansen [9] found that participants picked out the lone angry face from the happy faces more quickly than they picked out the happy face from the angry face grids. It suggests that angry face may be searched in a preattentive and parallel way. Öhman et al. [22] extended to find that threatening angry faces were more quickly and accurately detected than were other negative faces, including sad and scheming. This attentional bias was also been replicated in an emotional Stroop color-naming task [26]. The color-naming latencies were longer for words with undesirable traits than that with desirable traits. It means attention is automatically drawn away from the color-naming task to undesirable stimuli more than it is drawn to desirable stimuli.

Although the negativity bias has been documented by considerable behavioral studies and many researchers agree that it has an evolutionary origin, there still must be a set of neural substrates and psychophysiological mechanisms that directly modulate the bias. According to previous literatures [19], both automatic and controlled processes are involved in the bias. Animal and human studies [19,23,33,35] consistently claim that the amygdala plays an important role in the automatic process. It functions to determine whether incoming stimuli are threatening and, if so, rapidly associates the perception of those stimuli with the appropriate response. While some other neural structures, such as the anterior cingulate cortex, the orbital and ventromedial frontal cortex, which function as conflict monitoring and context-dependent action selection, are involved in the controlled emotion process [7,11,29]. Despite all the findings, it is still unclear how the emotion processing is manipulated by neural mechanisms. More work from various aspects and different technological approaches is needed.

Event-related potential study is one of the accesses to explore the underlying neural mechanisms of negativity bias, especially attentional bias which may occur rapidly after signal onset. In two studies [27] participants were instructed to evaluate positive and negative pictures embedded in positive or negative

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backgrounds, or in a neutral context produced by an oddball paradigm, respectively. The results showed that P1 amplitude to frequent stimuli and to rare negative stimuli were larger than that to rare positive stimuli. In another experiment [2] with an implicit emotional task, they found that P200, an attention-related component, showed higher amplitudes and shorter latencies in response to negative stimuli than in response to positive stimuli. It was found that amplitudes of P1, P2 and P3b were modulated by valence content in a non-emotional visual oddball task, suggesting it occurred at several points in the information-processing stream [5]. In a direct valence judgment task, the emotional negativity bias was also observed in several temporal stages distinguished by attention, evaluation and reaction readiness [12].

From ERP studies mentioned above, we can conclude that negative stimuli can attract attention preferentially compared with non-negative stimuli. And the attentional bias may occur in very early stage of information processing. It implies that its subjacent mechanism may be an automatic way, i.e., the negative information can resist the attention shortage and be processed preattentively. The implicit task used by Carretié et al. [2] is a good way to test the preattentive processing. However, in their study all the emotional stimuli were presented in the attentional focus although the participants were not instructed to care about the emotional attributes subjectively. In the current study, a cue-target paradigm [8,14,21,24] was applied to attain two conditions: within attentional focus and out of attentional focus, i.e., sufficient attention and insufficient attention. An implicit task was used to avoid the task relevance effect [4]. In one word, the present study aimed to explore the neural mechanism of attentional bias occurring in the insufficient attention condition.

Seventeen right-handed healthy undergraduates aged between 20 and 22 years (mean = 20.3) were included in this study. Eight of whom were male.

Same number of positive, negative and neutral pictures was selected out from the International Affective Picture System (IAPS) [15] and the Chinese Affective Picture System (CAPS) [1] which was established to fit our native subjects. There included forty pictures in each emotional category (20 from IAPS and 20 from CAPS). The positive and negative pictures were matched according to their normative valence extremities and arousal values which were collected from the previous surveys [1,13]. The positive and negative stimuli had equal valence extremity (positive valence $M = 7.44 \pm 0.27$, negative $M = 2.45 \pm 0.21$), and equal arousal (positive $M = 5.77 \pm 0.60$, negative $M = 5.98 \pm 0.77$). The mean valence of neutral pictures was 5.03 ± 0.11 , the mean arousal was 4.01 ± 0.97 . Each picture was inverted by an image software and then was composed with the original picture in a upper or lower adjacent position (Fig. 1). Each patchwork was sized 8 cm × 12 cm.

The participants were told that they would be watching pictures on a computer monitor located approximately 70 cm in front of their eyes. The stimuli presenting procedure would follow a ‘fixation-cue-target-response signal’ sequence. In the beginning of each trial, a white cross (0.7 cm × 0.7 cm) on a black background was presented at the center of the screen as



Fig. 1. An example of the target pictures. Its upright part (normal scene) is located in the upper position of the whole patchwork.

the fixation point for 500 ms. Then a white quadrangle flashed randomly at the left or right side of the screen, which served as a location cue (60% valid and 40% invalid). The center of the cue located at the same horizontal level with the fixation cross. Its horizontal visual angle was 7.4° and the vertical angle was 9.8° . The target picture, i.e., the patchwork described above, had the same visual angles with the cue and it was presented for 500 ms after an ISI ranged from 150 to 350 ms randomly. The participants were instructed to discriminate whether the normal scene located at the upper or lower part of the whole patchwork. They were also told not to respond until there appeared a green round with a 2 cm diameter on the screen after 1000 ms from the offset of the target. The response window would last for 1500 ms and the participants should push ‘f’ on the keyboard with left index finger if the normal scene was at the upper position, or else push ‘j’ with right index finger to indicate it was at the lower position. The green round would disappear after response. The inter-trial interval (ITI, offset to onset) ranged between 700 and 1000 ms randomly.

Electroencephalogram (EEG) data were recorded from 64 scalp sites using AgCl electrodes mounted in an elastic cap (NeuroScan Inc.), with the linked reference on the left and right mastoids. The vertical electrooculogram (EOG) was recorded

Table 1
Accuracy rates (%), $M \pm SE$ by cue validity and emotional valence

Cue validity	Positive	Neutral	Negative
Valid	93.22 \pm 2.39	94.21 \pm 2.10	94.53 \pm 3.01
Invalid	91.37 \pm 3.58	89.67 \pm 1.89	90.62 \pm 2.40

supra- and infra-orbitally at the left eye. The horizontal EOG was recorded from the left versus right orbital rim. Electrode impedances were below 5 k Ω . A bandpass of 0.05 to 70 Hz was used for the recording amplifiers. The EEG and EOG data were digitized continuously at a sampling rate of 500 Hz/channel. A regression procedure was used in which variance correlated with vertical EOG activity was removed from the EEG signal. Trials with peak-to-peak deflection exceeding $\pm 80 \mu\text{V}$ were excluded from averaging.

Average ERP waveforms were constructed according to the 2 (cue: valid and invalid) by 3 (valence: positive, negative and neutral) design.

The averaging epoch was 350 ms including a 50 ms pre-onset baseline. The ADJAR technique [34] was used to eliminate the overlapping influence of cue wave on the early components evoked by the target. The following 8 electrode pairs were chosen for statistical analysis: F1/F2, F3/F4, FC1/FC2, FC3/FC4, C1/C2, C3/C4, CP1/CP2 and CP3/CP4. P2 wave evoked by target was measured in the 160–240 ms time window. Its latencies and amplitudes (baseline to peak) were analyzed using repeated-measures ANOVA with cue validity, valence, hemisphere lateralization and electrode site as factors. The Greenhouse–Geisser epsilon correction was applied to adjust the degrees of freedom of the F -ratios.

Since the participants were not asked to give response as soon as possible, the reaction time was not included in statistical analysis. Analyzing accuracy rates (ACC), it was found that cue validity had a significant main effect [$F(1, 16) = 4.37, p < 0.05$]. Mean ACC was higher with valid cueing than with invalid cueing (Table 1). None of the other main effects or interactions for mean ACC was significant.

Fig. 2 shows the grand averages of P2 elicited by each cue validity \times valence condition. There were significant main effects

of P2 amplitude for all the statistical factors [validity: $F(1, 16) = 8.68, p < 0.05$; valence: $F(2, 32) = 18.73, p < 0.01$; hemisphere lateralization: $F(1, 16) = 14.52, p < 0.01$; electrode site: $F(7, 112) = 21.57, p < 0.001$]. The largest amplitude appeared in the anterior-central sites (e.g., FC1/FC2 and FC3/FC4). The amplitude in the condition of valid cueing was larger than that in invalid cueing. Negative pictures evoked higher wave than positive and neutral pictures. The amplitude in the right hemisphere was larger than that in the left hemisphere. There was also a validity \times valence interaction [$F(2, 32) = 9.45, p < 0.05$], so simple effect analyses were conducted further. It was found that in valid cueing as well as invalid cueing, negative stimuli always elicited higher amplitude than positive and neutral stimuli [$F(2, 32) = 13.24, p < 0.01$; $F(2, 32) = 21.55, p < 0.01$]. In positive and neutral conditions, the amplitude in valid cueing was larger than that in invalid cueing [$F(1, 16) = 9.36, p < 0.05$; $F(1, 16) = 12.47, p < 0.01$]. While in negative condition, cue validity had no influence on P2 amplitude [$F(1, 16) = 1.34, p > 0.05$].

In this experiment we used a peripheral cueing paradigm to manipulate the distribution of attentional resources. The peripheral cue attracts attention automatically and strongly [8,14,21,24]. This was evidenced again by the current behavioral data. Despite the high accuracy rates (above 90% in general) in all the experimental conditions, there was still a significant difference between the valid cueing and the invalid cueing condition. The subjects performed better with sufficient attention than with insufficient attention, which was consistent with the cognitive processing laws. From ERP data we observed higher P2 amplitude in the valid condition than that in the invalid condition. It suggested that more psychological resources were recruited by the valid cue. All these data indicated that it was successful to manipulate the attentional resources in the current study.

Unlike the valence judgment task applied in some other studies [12,27], in this experiment the subjects were not asked to care about the emotional property of the stimuli, which helped to prevent the subjects from supposing certain category of stimuli was more important than others so paying more attention to them voluntarily or involuntarily [2]. In this study, the direction and the position of the picture were judged explicitly, and simultaneously the emotional contents were processed implic-

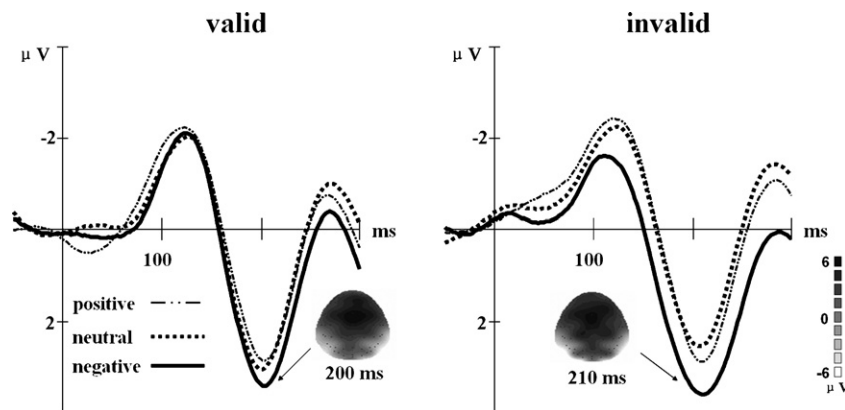


Fig. 2. Grand averages in C1 electrode site for the three emotional conditions under valid cueing and invalid cueing showed that negative pictures evoked larger P2 amplitudes than non-negative pictures. The topographical maps for negative condition indicated that (a) P2 was maximal at the anterior-central sites; (b) there was no significant change on P2 amplitude between valid cueing and invalid cueing condition; (c) there was a right hemisphere lateralization in emotional processing.

itly. In all the conditions the explicit task was identical, so the differences of ERP amplitudes should be attributed to the different emotional properties of the stimuli. As for the relationship between the explicit task and the implicit task, there may be two kinds of situations [10]. On the one hand, emotional contents may interfere with the explicit task, so the subjects have to inhibit the emotional processing to ensure the direction judgment. If there exists a negativity bias, negative materials which have stronger interference effect will recruit more energies and evoke larger ERP amplitudes. Of course, on the other hand, emotional contents may be processed automatically and rapidly, so the implicit task may be accomplished ahead of the explicit task. There is no competition between the two tasks, moreover, emotional contents can activate the activities of the brain so more attentional resources are accessible, i.e., emotional processing may facilitate the direction judgment. The stimuli which own stronger activating ability will evoke larger amplitudes. In the current study the subjects were not required to respond as early as possible, so we can not know whether there exists a facilitating or interfering effect from the reaction time. There was no accuracy difference among the three emotional conditions, so we cannot deduce the relationship of the two tasks. Nevertheless, it would not influence our exploration on emotional negativity bias from the electroencephalogram data.

This study found a positive-going component, named P2, which reached its peak value at about 200 ms after stimulus onset and was maximal at the anterior-central scalp sites. Its amplitude was modulated by cue validity as mentioned above, and associated with the emotional valence of the stimuli (to be discussed below). These characteristics are similar to the P2 component described in previous literatures [2,18], in which P2 is thought to be related to selective attention. So in this study we use P2 as a physiological mark to analyze the relationship between emotion and attention.

In previous implicit tasks [2,5] the target was often presented within the attentional focus. In order to control the attention allocation more strictly, we used the peripheral cueing paradigm to realize sufficient attention and insufficient attention condition. From the analysis of P2 component it was found that negative condition evoked the highest amplitude among the three emotional conditions. Since P2 is an attention-related component [2,3,18], this result supports the attentional bias strongly. Furthermore, it was found that in valid and invalid cueing, there was no significant change of the amplitude elicited by negative stimuli. In other words, emotional processing of negative information was not modulated by the cue validity. It seems that to some extent negative stimuli can resist the shortage of attentional resources. They can activate more or stronger neuronal activities with limited psychological resources compared with other kind of information. It suggests that this kind of information may possess a preferential status in neural mechanism. Psychological resources are allocated preferentially to the information which seems more urgent to the security and survival of organism [19].

From the current results, we can see that the attentional bias occurred very early (about 200 ms after stimuli onset which was indexed by P2) in information processing. P2 is a component on

the boundary of consciousness and unconsciousness so the bias may be manipulated by automatic mechanism in some extent. According to literatures to date [16,20,32,29], there are two routes by which emotional information is processed: the first is a cortically based system used to recognize stimuli on the basis of distinct perceptual features; the second consists of more direct connections to sensory organs via the thalamus, bypassing the longer cortical route. Dr. Joseph LeDoux suggests that the subcortical pathway provides a quick analysis of the affective properties of stimuli that serves as an initial template for subsequent processing [16]. His conclusions have been supported by some studies. It was found that brief, backward-masked presentations of fearful but not happy faces activated the amygdala even though participants were unaware that either type of face had been presented [32]. A similar experiment found that the pathway of activation passed through the thalamus and amygdala but bypassed the cortex [20]. Maybe this route is the most important mechanism that underlies the automatic process of negativity bias. It is easy to understand the usefulness of a negativity bias from an evolutionary viewpoint. Undoubtedly, quick analysis and prompt reaction mean more chances in the survival competition. However, there are still much unknown about how the emotional activities are initiated and modulated.

It has been explored for a long time about the temporal course of emotional processing. The present results and some other studies [2,3,12] showed that the attentional bias occurred at about 200 ms after stimuli onset. While there were reports that P1 amplitude was modulated by emotional properties, suggesting the bias might occur earlier [25,27]. No doubt the variation of experimental designs is one of origins for this inconsistency. Additionally, we should recognize that maybe such instability is just the manifestation of the intrinsic characteristics of the attentional bias. There may be an accumulative effect in the bias and the current techniques cannot measure it when it is still very weak in the beginning. When it comes to its critical time, e.g., 100 ms, the bias emerges but is not so stable. Again, although the attentional bias can occur automatically, it may require some quantity of psychological resources [23]. Sometimes the accessible resource is too little to support the work, so the bias will not occur or be delayed to a later time, e.g., 200 ms. Thus, the results from different studies seem not so consistent.

The present study also observed that in all the emotional conditions the amplitudes in the right hemisphere were larger than that in the left hemisphere, i.e., there was a hemisphere lateralization of emotional processing. This result is consistent with the right lateralization hypothesis [6,17,28,31], in which the right brain hemisphere is the dominant hemisphere in emotional activities and it is activated stronger than the left side in emotional processing. However, what revealed by this study is only a rough description about emotional lateralization. Meta analysis [30] indicated that in current situations it was no longer appropriate to discuss the lateralization in a unit of hemisphere. Different brain areas or neural structures may have their own characteristics on this question. More elaborate work is needed in the future.

In conclusion, this study suggests that negative information possesses a preferential status in emotional processing and it

can resist the attention shortage to some extent. An automatic mechanism may manipulate this phenomenon, which ensures organisms respond to dangerous signals in the outer environment preferentially and gain more chances in survival competition.

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