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EMOTIONAL AROUSAL TO NEGATIVE INFORMATION AFTER TRAUMATIC EXPERIENCES: AN EVENT-RELATED BRAIN POTENTIAL STUDY

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Abstract—Event-related brain potentials (ERPs) during an emotional Stroop task were measured in two groups of participants: 14 participants who had experienced the great Sichuan earthquake (earthquake group) and 14 participants who did not experience the earthquake (control group). ERP data showed that negative words elicited a more negative P2 than positive words in the earthquake group. Moreover, negative words also elicited a more negative ERP deflection (N280-380 effect) than positive words in the earthquake group, while this effect was not found in the control group. We suggest that the N280-380 effect may reflect heightened emotional arousal to negative words due to personal experience of a traumatic event. Dipole analysis localized the N280-380 to the parahippocampal gyrus and the cuneus, which we suggest may be related to the automatic recollection of the traumatic experience.

Key words: emotional arousal, negative information, event-related brain potentials (ERPs).

The emotional Stroop task is a widely used methodology to evaluate emotional negativity bias (Williams et al., 1996; Wells and Mathews, 1996). In this paradigm, participants are shown words of varying emotional significance, and asked to name the colors in which the words are printed while ignoring the meanings of the words. Delays in color-naming speed (i.e. Stroop interference) occur when the meaning of the word automatically demands the attention of the participant despite the instructions to attend to the color of the word (MacLeod et al., 1986). The emotional Stroop task is utilized by researchers to explore the nature of automatic and controlled cognitive processes, as well as disturbances in cognition resulting from various psychiatric and neurological disorders (McNally et al., 1993; Fehr et al., 2006; Engels et al., 2007).

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Abbreviations: EEG, electroencephalograph; EOG, electrooculogram; ERP, event-related brain potentials; PCA, principal component analysis; PTSD, post-traumatic stress disorder; PTSD-SS, post-traumatic stress disorder self-rating scale; RT, reaction time.

Several studies have indicated that negative information elicits more prominent responses than neutral or positive information in the emotional Stroop task, and this is interpreted as indicating enhanced attention toward more salient stimuli (Hansen and Hansen, 1988; McNally et al., 1994; Williams et al., 1996; Compton et al., 2003; Thomas et al., 2007; Taake et al., 2009). Central to these cognitive theories is the notion that such preoccupation arises from biases in attention (Williams et al., 1996). For example, participants with anxiety disorders are thought to show a heightened sensitivity to emotionally negative information (MacLeod et al., 1986; Hansen and Hansen, 1988). Studies investigating the emotional Stroop effect in participants with post-traumatic stress disorder (PTSD) have also found slower reaction times (RTs) in naming word colors, and in particular, for traumatic words, suggesting an attentional bias toward trauma-related information (McNally et al., 1994; Metzger et al., 1997). For example, McNally et al. (1994) demonstrated that Vietnam combat veterans with PTSD exhibited Stroop interference effect for trauma-related words but not for other threat words, positive words, or neutral words. There are multiple studies that report negative biases toward emotional information in PTSD. However, no study to date has investigated this phenomenon in trauma exposed but nonpathological samples or subclinical groups.

Event-related brain potentials (ERPs) with a high temporal resolution have been used to identify the temporal stages of emotional negativity bias (Huang and Luo, 2006). ERPs were originally called evoked potentials (EPs) because they are electrical potentials evoked by stimuli. ERPs have a temporal resolution of 1 ms or better under optimal experimental conditions. In contrast, hemodynamic measures are limited to a resolution of several seconds by the sluggish nature of the hemodynamic response. Amplitudes of ERP components are generally assumed to signify the degree or intensity of the engagement of cognitive processes, and latencies are thought to measure the time course of stages of processing (Luck et al., 2000). Some ERP studies have found large amplitudes in response to emotionally negative relative to emotionally positive stimuli, suggesting that preferential processing is apparent when examining ERP rather than RT measures (Carretié et al., 2001; Thomas et al., 2007). Thus, ERPs may provide a more precise picture of the time course of attentional biases. Moreover, ERP data may help to clarify the nature of brain activation associated with cognitive processing of emotional and neutral stimuli and distinguish

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spontaneous attention to emotionally negative information during different stages of perceptual identification.

In our previous study, a modified earthquake color-matching Stroop task was used to investigate the neurophysiological substrates of recent exposure to serious earthquake (Wei et al., 2010). We found a Stroop interference effect for trauma-related information in the earthquake group (trauma exposed nonpathological sample). Specifically, incongruent stimuli (the information of color and meaning did not match) elicited a more negative ERP deflection (N300-450) than did congruent stimuli in the earthquake group, while the N300-450 effect was not found in the control group. These results showed that the N300-450 effect might reflect difficulties in conflict resolution in the early phase of perceptual identification due to sensitivity to the specific stimulus. However, it is still unclear whether the degree of exposure to this stressor may be related to differences in patterns of ERP activation to negative emotional stimuli in general. Many studies indicate that participants are excessively sensitive to emotionally negative information after experiencing traumatic events (e.g. MacLeod et al., 1986; Hansen et al., 1988; McNally et al., 1993; Fehr et al., 2006; Goldstein et al., 2007). There is also preliminary evidence that these participants demonstrate increased amplitude of early ERP components in relation to salient negative stimuli relative to healthy participants (e.g. Bar-Haim et al., 2005).

Therefore, in the current study, we explored the neural correlates of stress-modulated cognitive processing using the emotional Stroop task. Two groups were studied: a trauma exposed nonpathological group (earthquake group) of 14 Chinese people who had experienced the Sichuan earthquake close to its epicenter and a control group of 14 participants who had not experienced the earthquake. It is well known that the emotional Stroop task offers an effective methodology with which to investigate how traumatic experience may modulate the electrophysiological correlates of the negative bias to emotional words in early perceptual identification (Fehr et al., 2006; Goldstein et al., 2007). Thus, based on previous studies (e.g. MacLeod et al., 1986; Hansen et al., 1988; McNally et al., 1993; Fehr et al., 2006; Goldstein et al., 2007), we hypothesized that the earthquake group would have stronger emotional arousal to general negative stimuli (not earthquake related) than the control group due to previous traumatic experience. Specifically, we predicted that negative words would elicit a more negative ERP deflection than positive words in the early processing of emotional words in the earthquake group compared to the control group.

EXPERIMENTAL PROCEDURES

Subjects

Approximately 6 months after the Sichuan earthquake, 17 participants (Deyang city, PR China) who had experienced the earthquake were asked to complete a self-report questionnaire: the post-traumatic stress disorder self-rating scale (PTSD-SS) (Liu et al., 1998). The PTSD-SS was constructed based on the definition and diagnostic criteria of PTSD described in the Diagnostic and Statistical Manual of Mental Disorders: Fourth Edition (DSM-IV), they thought that participants who have got the total score below 60 have no serious PTSD symptom (Liu et al., 1998). We know that Deyang is one of three major cities immediately surrounding the earthquake's epicenter (Wenchuan, approximately 60 miles). There were about 4 million people, encountered severe casualties, with a current death toll of 6000. Fourteen participants who had got the total score below 60 were selected as the earthquake group (eight women, six men; aged 19–23 years; mean age, 21.6 years; mean score: 42.1±13.2). That is, participants only experienced the earthquake but not suffer from longer-term problems (nightmares, flashbacks) after it. In the control group, 14 participants (Chongqing city, PR China) without earthquake experience were selected as the control group (eight women, six men; aged 19–23 years; mean age, 20.8 years; mean score: 16.9±10.4). We had obtained appropriate ethics committee approval for the research, and all participants gave written informed consent. All of them were right-handed, had no current or past neurological or psychiatric illness (their instructors confirmed that they had no any abnormal behavioral or psychological phenomena in the past by checking their entrance psychological archives), and had normal or corrected-to-normal vision.

Stimuli and procedure

The experimental materials consisted of valenced words (positive or negative, e.g. cheer, delight; grief, pain, respectively) presented in different color (red or green). All words were general in their nature (i.e. not related to the earthquake). There were 30 stimuli for each color (red, green) and valence (positive, negative) category; thus, there were 120 stimuli in total. Positive and negative words were matched for arousal, word frequency and complexity of the characters. The size of the Chinese words was Song Ti No. 20 [1.6° (horizontal)×0.8° (vertical)], and words were displayed in the center of a 17-inch screen at random order.

Participants were seated in a semi-dark room facing a monitor placed 60 cm from their eyes. They were instructed to rest their right index and right middle finger on the "1" and "2" buttons on the keyboard, each designated to indicate red or green color. These stimulus–response key assignments were counterbalanced across individuals. All participants were told that a gray cross would appear in the center of the screen serving as a fixation point, followed by one word written in color. The fixation point appeared for 300 ms and then each word appeared for 1500 ms. Participants were asked to ignore the meaning of the words and identify the color in which the stimulus was written as quickly as possible, and to respond by pressing the designated button of the corresponding color. The experiment was divided into a practice phase and a test phase. The practice phase was designed to rehearse the mapping of colors onto fingers and pressing of the response buttons. When the accuracy rate for each individual reached 85%, the practice phase was ended. The formal test phase consisted of two blocks. Each block had 60 judgment trials in which the stimuli were presented in individually varying randomized sequences. Participants were instructed to try their best to avoid blinking and making eye movement of any sort and to keep their eyes fixated on the monitor rather than looking down at their fingers during trial phases. Participants were able to rest after finishing each block.

Electrophysiological recording and analysis

Brain electrical activity was recorded from 64 scalp sites using tin electrodes mounted in an elastic cap (Brain Product), with the reference on the left and right mastoids. The vertical electrooculogram (VEOG) was recorded with electrodes placed above and below the left eye, and the horizontal electrooculogram (HEOG) with electrodes placed by right side of right eye and left side of left eye. All interelectrode impedance was maintained below 5 kΩ.