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# Attention bias in earthquake-exposed survivors: An event-related potential study

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ABSTRACT

The Chinese Wenchuan earthquake, which happened on the 28th of May in 2008, may leave deep invisible scars in individuals. China has a large number of children and adolescents, who tend to be most vulnerable because they are in an early stage of human development and possible post-traumatic psychological distress may have a life-long consequence. Trauma survivors without post-traumatic stress disorder (PTSD) have received little attention in previous studies, especially in event-related potential (ERP) studies. We compared the attention bias to threat stimuli between the earthquake-exposed group and the control group in a masked version of the dot probe task. The target probe presented at the same space location consistent with earthquake-related words was the congruent trial, while in the space location of neutral words was the incongruent trial. Thirteen earthquake-exposed middle school students without PTSD and 13 matched controls were included in this investigation. The earthquake-exposed group showed significantly faster RTs to congruent trials than to incongruent trials. The earthquake-exposed group produced significantly shorter C1 and P1 latencies and larger C1, P1 and P2 amplitudes than the control group. In particular, enhanced P1 amplitude to threat stimuli was observed in the earthquake-exposed group. These findings are in agreement with the prediction that earthquake-exposed survivors have an attention bias to threat stimuli. The traumatic event had a much greater effect on earthquake-exposed survivors even if they showed no PTSD symptoms than individuals in the controls. These results will provide neurobiological evidences for effective intervention and prevention to post-traumatic mental problems.



## 1. Introduction

Numerous studies have indicated that exposure to traumatic events may leave deep invisible scars, including psychotic symptoms, on survivors. Post-traumatic stress disorder (PTSD) is the most prevalent among psychotic symptoms. Generally, only a substantial minority of people exposed to traumatic events develop PTSD, which is possibly related to individual traits that increase vulnerability (Stam, 2007). However, trauma survivors without PTSD have received little attention in previous studies. Studies indicated that there was significantly different neurobiological response pattern between PTSD patients and trauma survivors without PTSD. For example, Hendler et al. (2003) reported an increase in amygdala activation in response to trauma-related stimulus in PTSD patients, but not in traumatized participants without PTSD. The variations in sensitivity of the amygdala to traumatic context imply the distinct roles of limbic and sensory regions in the registration and recollection of emotional experience (Hendler et al., 2003). Especially, few studies have included traumatized participants who did not develop PTSD shortly after the Chinese earthquake (Lui et al., 2009; Wei et al., 2010). The results of Lui et al. (2009) revealed that the non-PTSD participants showed significant alterations within 25 days after the Chinese earthquake in brain function similar to those in PTSD patients and proposed that negative life events might affect cognitive and brain functions in people who experienced the Chinese earthquake. Wei et al. (2010) investigated 20 participants who had experienced the Chinese earthquake and 20 participants without earthquake experiences as the control group using the modified Stroop task on event-related potentials (ERPs). They found that incongruent stimuli elicited a more negative ERP deflection (N300–450) than did congruent stimuli in the earthquake group but not in the control group. Nevertheless, an increasing number of studies have reported that traumas and the development of psychopathology can create lasting changes (McEwen, 2000). However, previous studies were performed shortly or less than one month after the Chinese earthquake and the longer term effects were lacking. Information on whether this finding represents a slowly

*Abbreviations:* PTSD, posttraumatic stress disorder; ERPs, event-related potentials; EEG, electroencephalogram; EOG, electrooculogram; EMG, electromyographic; ANOVA, analysis of variance; ACC, accuracy rates; RTs, reaction times.

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evolving pattern of brain alteration or the survivors recovered from the traumatic experiences is insufficient. Thus, the present study was carried out two years after the Chinese earthquake in 2008.

There was a strong link between the subjectively assessed behavioral phenomenology of PTSD and objective neurobiological markers. For example, Morey et al. (2008) found that activation for emotional compared with neutral stimuli was highly positively correlated with level of PTSD symptoms in ventral frontolimbic regions, notably the ventromedial prefrontal cortex, inferior frontal gyrus, and ventral anterior cingulate gyrus. Conversely, activation for the executive task was negatively correlated with PTSD symptoms in the dorsal executive network, notably the middle frontal gyrus, dorsal anterior cingulate gyrus, and inferior parietal lobule. A number of neuroimaging studies have used functional and structural imaging to indicate alterations in brain function in PTSD patients (Karl et al., 2006b; Lanius et al., 2006). However, ERPs can indicate various stages of attention processes because of its high time resolution contrast to functional neuroimaging studies, such as *f*MRI. For example, Buckley et al. (2000) indicated that individuals with PTSD showed attention bias toward trauma-related stimuli in post cognition stages of information processing.

The dot-probe paradigm is often selected as an experimental paradigm to explore the nature of attention bias (Eldar and Bar-Haim, 2010; Eldar et al., 2010) because it is a facilitation paradigm that would index a processing bias toward threat materials if participants with PTSD would be faster to respond to target words when they are located adjacent to threat words as opposed to when they are located distant from threat words. A number of studies have used either facilitation or modified dot-probe paradigm to determine whether negative stimuli is preferentially processed, relative to neutral or positive stimuli, of PTSD populations. For example, Bryant and Harvey (1997) found a facilitation effect for threat words, relative to neutral words in the PTSD group in a modified dot-probe paradigm. Moreover, ERP dot-probe studies have shown that threat-related modulation in the C1 component (50–100 ms post-stimulus) was more intense for displays containing threat stimuli relative to displays containing non-threatening stimuli (Pourtois et al., 2004). While the P1 component (130 ms post-stimulus onset) was found to be enhanced for targets replacing threatening stimuli compared to non-threatening stimuli, which was attributed to greater attention allocation to the threatening relative to non-threatening stimuli, and are in line with basic ERP spatial attention research showing P1 modulation by early visuospatial orienting (Eldar et al., 2010; Pourtois et al., 2004). Consistent with previous studies in PTSD patients, Metzger et al. (2008) used an identical twin case–control design to reveal that the PTSD group had significantly steeper P2 amplitude intensity slopes and found that increased P2 intensity dependence is an acquired consequence of PTSD.

So far experimental studies examining neurobiological attention bias underlying earthquake traumatic events are rare. Specifically, ERP evidence of attention bias in traumatized participants without PTSD is insufficient. Here, we compare the attention bias of survivors of the Chinese earthquake who did not develop PTSD symptoms with that of healthy controls to earthquake-related words and neutral words. The target probe presented at the same space location consistent with earthquake-related words was the congruent trial, while the space location with neutral words was the incongruent trial. In terms of our pilot experiment, words were presented for 300 ms, 500 ms, and 1000 ms in the dot-probe paradigm. Results showed no significant differences on behavioral and ERP responses between congruent trials and incongruent trials ($p > 0.05$). The results of Bryant and Harvey (1997) suggested that the PTSD group had an involuntary processing bias toward disorder-specific threat stimuli. In addition, there is some debate as to whether there is a single type of automatic processing, as opposed to multiple types of automatic processing, which is as to whether the dot-probe paradigm can automatically assess independently (Buckley et al., 2000). Accordingly, we presumed that the earthquake-exposed group might have involuntary attention bias to earthquake-related stimuli with a subliminal exposure time. Thus, we chose the masked version of the dot probe task.

Based on previous studies mentioned above, the earthquake-exposed group may be more sensitive to earthquake-related stimuli than the control group. Additionally, ERPs in children might differ from those in previous studies of adults. For example, Perez-Edgar and Fox (2003) used the emotional Stroop with 11-year-old children and found that negative words appeared to tax attentional and processing resources more than positive words in the ERP study, and early (P1–N1–P2–N2) components were presumed to reflect automatic attentional processes, indicating that early perceptual processing may activate latent biases in attentional allocation. In another study, Perez-Edgar et al. (2006) examined 33 children of parents with childhood-onset depression (COD) using the Posner cued attention task. Their performance was marked by significant decreases in RTs and increase in errors under the affective condition relative to performance under neutral conditions, and they also showed larger P3 and slow wave amplitudes in anterior scalp sites compared with control children. Accordingly, we hypothesized that the earthquake-exposed group may be associated with rapid and enhanced orienting of processing resources to earthquake-related words compared with the control group, and that congruent trials would elicit faster response, shorter ERP latencies and greater earlier ERP components (such as C1, P1 and P2) in the earthquake-exposed group than in the control group.

## 2. Methods

### 2.1. Participants

The volunteer participants were recruited from two middle schools. Earthquake-exposed participants were recruited from the disaster area located 145 km from the epicenter of the 2008 Chinese earthquake, and the controls from non-disaster area (Zhang et al., 2010). Participants were initially screened for selection criteria through an assessment. Based on the assessment, the participants who met selection criteria following the assessment of PTSD were excluded from the study. Moreover, the participants were excluded from the study if they had a previous or current presence of traumatic experiences. All participants were right-handed and had normal vision and no self-reported history of neurological or psychiatric disorder.

Accordingly, 13 earthquake-exposed middle school students (7 boys, 6 girls) and 13 healthy age- and sex-matched unexposed controls (7 boys, 6 girls) were tested in all domains of the study. However, none of the participants reached the DSM-IV diagnostic criteria for PTSD. All participants signed an informed consent in accordance with the Ethical Principles of Psychologists, and the study was approved by the Mianyang Normal University Ethics Committee. All participants were paid for their participation after they were investigated.

### 2.2. Stimuli

The cue words included 35 earthquake words [e.g., 流血 (blood), 余震 (aftershock)], and 35 neutral words [e.g., 思想 (thinking), 文件 (file)] (Qiu et al., 2009; Wei et al., 2010). All the words were used to describe ordinary things in Chinese daily life. Earthquake words often appeared in the earthquake (e.g., blood, pumper). Earthquake words and neutral words were matched by their length (two words) and their frequency (high frequency) in the Chinese language. The size of Chinese words was Song Font No. 20 [1.6° (horizontal) × 0.8° (vertical)], and was displayed in the center of a 17-in. screen.

### 2.3. Procedure

The study consisted of two parts. In the first part, a psychometric assessment was conducted. In the second part, the EEG was recorded in the experiment.