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Processing Emotional Facial Expressions in Individuals with Post-traumatic Stress Symptom: An ERP Study*

Yu-Sun, Lee **Jang-Han, Lee†**

Department of Psychology, Chung-Ang University

The present study aimed to demonstrate the neural mechanisms that relate to the abnormal processing of facial expressions in individuals with post-traumatic stress symptom (PTSS). In particular, we investigated each processing stage's influence on facial expression recognition in individuals with PTSS. To investigate these mechanisms, we measured behavioral performances and event-related potentials (ERPs) as individuals performed a multi-morphed facial expression identification task. Participants were divided into two groups: those with PTSS and a control group without PTSS. Participants viewed representations of fearful, neutral, and happy facial expressions. ERP results revealed that, relative to the control group, the PTSS experience group experienced enhanced P1 amplitudes (reflecting rapid detection) and attenuated LPP amplitudes (reflecting later strategic processing) for all facial expressions. The behavioral data show that PTSS experience group committed more errors and were slower at detectingfacial expressions than were the controls. The difficulties individuals with PTSS face in recognizing facial expressions are explained by abnormal processing related to sustained attention or elaborating processing deficit.

Key words : post-traumatic stress symptom, social function deficit, facial expression, event-related potentials (ERPs)

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† 교신저자(Corresponding Author) : Jang-Han, Lee / Associate Professor, Department of Psychology, Chung-Ang University / 221 Heukseok-dong, Dongjak-gu, Seoul 156-756, Korea
Fax : 02-816-5124 / E-mail : clipsy@cau.ac.kr

Introduction

One of the most common characteristics of individuals diagnosed with post-traumatic stress disorder (PTSD) is impairment in social functioning (American Psychiatric Association, 2000; Olatunji, Cisler, & Tolin, 2007). The quality of a person's interpersonal relationships depends on that individual's ability to process social information (Cooley & Nowicki, 1989; Sta. Maria, 2002). In particular, the ability to interpret facial expressions is invaluable in successful social interactions, as such expressions represent other people's moods and attitudes, among other characteristics (Eimer & Holmes, 2002). Previous research suggests that social impairment in individuals with post-traumatic stress symptom (PTSS) may be directly related to these individuals' misinterpretations of nonverbal cues, such as facial expressions (McClure, Pope, Hoberman, Pine, & Leibenluft, 2003). As reestablishing a sense of connection to others is important for trauma survivors (Herman, 1997), understanding the mechanisms that underlie interpersonal connection difficulties is important for understanding PTSD (Gapen, 2009).

Some evidence supports the existence of abnormal processing of facial expressions in individuals with PTSS, in that they such people exhibit more interpretation errors and/or instances of negative interpretive bias (Gapen, 2009; Paunovic, Lundh, & Öst, 2003; Sta. Maria, 2002). However, not only is research into facial expression recognition ability in PTSS scarce, but no studies have yet explained why individuals with PTSS have difficulty in processing facial expressions. Putative causes include abnormal amygdala function and cognitive avoidance. Since the amygdalocentric emotional system mediates the “fight or flight” response, the threats of certain fearful stimuli may evoke avoidance (Foa, Steketee, & Rothbaum, 1989). Another possible explanation is that individuals with PTSS exhibit an overall cognitive deficit, indicating attenuated differentiation of threat vs. non-threat signals (Felmingham, Bryant, & Gordon, 2003; Thayler & Ruiz-Padial, 2006) and other deficits, according to sustained attention tests (Vasterling et al., 1998).

However, prior studies have primarily used prototypical facial expressions of the most powerful emotions as stimuli. In fact, people process a wide range of emotional stimuli in everyday life, including less intense signals. Probably, therefore, examining responses to intense facial expressions permits only a limited understanding of social cue processing in PTSS. In this context, assessing subjects' ability to quickly recognize traces of emotion or subtle changes in facial expressions is likely to yield important information for understanding PTSS-associated deficits in interpersonal functioning. The researcher must control the intensity level of experimental stimuli to elucidate the mechanisms related to facial expression processing.

Although previous studies commonly used behavior reaction times (RT) and imaging measures, both methods reflect an amalgam of processes and, therefore, may be insufficiently sensitive for capturing rapid, early cortical responses to facial expressions (Eimer & Holmes, 2007; Moser, Huppert, Duval, & Simons, 2008). Event-related potentials (ERPs), bycontrast, involve processing and acting on incoming information in a matter of milliseconds. Specifically, the ERP waveform represents multiple neural processes as discrete changes in specific components, offering several opportunities to detect processing (Moser et al., 2008). Thus, ERPs may be a more sensitive diagnostic method than RT or imaging is (Andres, Julieta, Adriana, & Fabiola, 2009). In this study, we used ERP data to investigate the processing mechanism of emotional facial expression, examining the ability for facial expression recognition and the effect of face emotional intensity in individuals with PTSS.

To our knowledge, only one recent study has examined the ERP correlates of facial expression processing in PTSD. Felmingham et al. (2003) demonstrated a general reduction in the amplitude of the ERP waveform's negative component, regardless of processing stage, and concluded that PTSD patients experience overall cognitive deficits in the context of processing facial expressions. However, since Felmingham et al. employed a passive facial expression-viewing task, whether this cognitive deficit affects both the initial rapid detection and later strategic processing during facial expression recognition is unclear. Findings from studies of individuals with anxiety spectrum disordermight help to resolve this problem. Holmes et al. (2008) suggested that anxious people show a clear dissociation pattern between early selective attention and later strategic processing. In other words, high anxiety (and possibly PTSD) may relate, in aversive stimuli, to the potentiate of initial threat evaluation and attenuation in later strategic processing (Holmes, Nielsen, & Green, 2008).

Recordings from scalp electrodes in ERP studies reveal a number of specific effects relating to emotional facial expression processing. During 100-200 ms post-stimulus, P1 components are sensitive to both physical stimulus factors and the index early sensory processing taking place in the extrastriate visual cortex. Resear chers have also demonstrated that when they employ a stimulus discrimination task, these potentials also respond to manipulations of both rapid detection and attention to emotional facial expression (Batty & Taylor, 2003; Pourtois et al., 2005). Following this enhanced positivity in posterior areas, the brain also engages in more detailed analysis of the visual information presented, as shown by the late positive potential (LPP). Emotional faces trigger a sustained positivity (or LPP) beyond 250 ms post-stimulus,with a broad frontoparietal scalp distribution (Ashley et al., 2004; Eimer &

Holmes, 2002; Meinhardt & Pekrun, 2003; Williams et al., 2006). These ERP modulations may reflect successive stages in the processing of emotional faces. Orbitofrontal mechanisms involved in the rapid detection of facial expression might generate the early positivity triggered within 200 ms of stimulus onset, while the later, more broadly distributed and sustained positivity likely reflects subsequent processing of emotional faces at higher-order decision and response-related stages, such as conscious evaluation of the facial expression's emotional content (Eimer & Holmes, 2007).

Therefore, in the present study we observed the posterior P1 and broad frontoparietal LPP components. This study aimed to demonstrate the neural mechanism for abnormal facial expression processing in individuals with PTSS during emotional facial expression recognition, by measuring the P1 and LPP component of ERPs. In particular, we identified processing stage impairments that, in both the initial rapid detection and later strategic processing stages, affected facial expression recognition in participants with PTSS. Additionally, we demonstrated the ways in which the sensitive PTSS experience group detected ambiguous social cues, specifically facial expressions.

Method

Participants

Participants were selected from 450 undergraduate students in Seoul, Korea (PDS-K; M=4.6, SD=7.0). We screened the students for prior exposure to trauma and PTSSs, using the Posttraumatic Diagnostic Scale from Foa et al. in its standardized Korean version by Nam et al. (PDS; Foa, Cashman, Jaycox, & Perry, 1997; PDS-K; Nam, Kwon, & Kwon, 2010). The PDS symptom severity scale comprises summed, self-report frequency ratings for each of the 17 symptoms in the DSM-IV (APA, 2000) PTSD criteria. The survey items assess the type of trauma experienced, as well as the severity of symptoms over the past month, on a scale ranging from 0 (not at all) to 3 (almost always). Based on the results of this screening, we sorted participants into two groups. Participants in the PTSS experience group (n=15) reported a trauma that met the DSM-IV PTSD criteria, specifically, an interpersonal trauma, such as experiencing or witnessing sexual or physical abuse, and scored 21 or more on the PDS (M=23.7, SD=3.0), which reflects at least a degree of PTSD symptom severity (Foa et al., 1997). 3.3% of the pool met the criteria for PDS-criterion. This rate is similar to the actual PTSD prevalence rate in Korea (about 2-3.5%; Cho et al., 2007). In addition, there was no significant difference in the time of trauma experiences in the PTSS experience group ($\chi^2(4, n=15)=2.87$, ns). The control group (n=15) comprised individuals who reported experiencing either no such trauma or a trauma not of the interpersonal type (witnessing a traffic accident = 4; disease or death of family member = 2; natural disaster = 1), did not have PTSS, and scored less than 5 on the PDS (M= 0.5, SD=1.4). The majority (n=6) had experienced these traumas more than five years previously. All participants had normal or corrected-to-normal vision, and were right-handed.

To assess participants for depressive and anxiety-related symptoms, we also had them complete the Beck Depression Inventory-Korean version (BDI-K; Lee & Song, 1991) and the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970), respectively. Table 1 shows the two selected groups' characteristics. The PTSS experience group's three scale scores were significantly higher than those of the control group. These results compared well to those previously reported for PTSD patient groups (e.g., Hayes et al., 2009).

Materials

Stimuli

Materials included 18 face pictures selected from the Korea University Facial Expression Collection (KUFEC; Lee et al., 2006), which we used to elicit participants' emotional responses. The face pictures that we selected were composed using emotional valence and arousal evaluating scores from 60 undergraduate students. Materials differed significantly in valence ($F(2,15)=77.85$, $p<.001$; happy= 6.8±0.5, neutral=4.7±0.2, fearful=3.6±0.4). In addition, there was no significant difference between the happy and fearful emotional arousal rating scores ($t(10)=1.9$, ns; happy=5.2±0.3, neutral=3.8± 0.4, fearful=5.7±0.6). The pictures represented males and females in equal numbers, and resembled one another in size, background,

Table 1. Demographic and clinical characteristics of subject sample

Characteristic	PTSS experience group (n=15)	Control group (n=15)	t / χ^2
Age	21.2 (1.9)	21.5 (2.0)	0.47
Gender, Number of females	13	13	
PDS	23.7 (3.0)	0.5 (1.4)	26.75**
BDI	14.6 (10.0)	6.1 (4.8)	2.97**
STAI-T	54.6 (9.8)	42.5 (7.5)	3.82**
STAI-S	47.4 (8.9)	36.5 (6.1)	3.92**

PTSS= post-traumatic stress symptom; PDS= Posttraumatic Diagnostic Scale;
BDI= Beck Depression Inventory Ⅱ; STAI= State Trait Anxiety Inventory, ** $p<.05$

spatial frequency, contrast grade, brightness, and other physical properties. Each picture was cropped into the shape of an ellipse using Adobe Photoshop 8.0 software, and the intensity of each facial expression was morphed using FantaMorph v4.0 (Abrosoft Inc.) All stimuli were covered from a visual angle of 8.6° × 7.5°. Each participant satin a quiet room with their eyes approximately 70 cm from a 17-in display screen. All stimulus displays appeared in the center of the screen.

Multi-morphed facial emotion identification task

We measured study participants' reaction times and correct labeling rates while they identified the displayed facial emotions, to determine how PTSD affects an individual's ability to identify a range of facial emotions. These facial stimuli were selected from Korean versions of an established set of photographs depicting faces with specific emotional expressions (Lee et al., 2006). Our set comprised standardized happy, neutral, and fearful faces in six different models (3 males, 3 females). For each model, we created a series of four variants of each emotional expression using morphing techniques (Blair et al., 1999). The 54 stimuli (4 intensity * 6 models * 2 emotion (happy & fearful) + 6 neutral emotional models) we used in the study ranged in intensity from neutral to 100% emotional (fearful & happy) faces. Emotional face' expression varied in intensity by intervals of 25%.

During the task, we asked participants to identify each of the 54 stimuli as happy, neutral, or fearful by pressing buttons 1, 2 or 3 as quickly as possible after each face's presentation. The stimuli's presentation order was randomized. Instructions appeared at the beginning of the task and also following the presentation of each stimulus. The instructions read, "what is the emotion? 1. Happy, 2. Neutral, 3. Fearful."

During the inter-stimulus interval, a fixation mark '+' appeared in the center of the screen, to help participants remain focused throughout the task. The face stimuli took 2000 ms each, with faces replacing the screen's central fixation cross for 500 ms, against a black background, at 1500 ms intervals.

Procedure

After participants received a general description of the experiment, we attached sensor electrodes to them and gave them detailed instructions for the task. Each participant was seated directly in front of the computer monitor and had 20 practice trials. Following these practice trials, participants completed 8 blocks of 54 trials (432 total trials), which emphasized both speed and accuracy.

Electroencephalogram Recording and Data Analysis

We recorded participant brain electrical activity from 28 scalp sites (FPz, Fz, FCz, Cz, CPz, Pz, Oz, FP2, F3/4, F7/8, FC3/4, C3/4, CP3/4, P3/4, P7/8, O1/2, T7/8, and FT7/8) using a tin electrode cap, with the references on the left and right earlobes. Additionally, we recorded electroculograms (EOGs) from the outer canthus of each eye, to determine horizontal electroculographic (hEOG) activity, and from the left eye, to measure activity, using bipolar recording. We kept electrode impedances below 5 kΩ and sampled electroencephalograms (EEGs) and EOGs online,with a digitization rate of 512 Hz. Following EEG recording, we digitally filtered the data via a band-pass filter, at 0.1-10 Hz, using Neuroscan software v4.3 (Compumedics Inc.). EEG and HEOG were epoched off-line relative to a 200 ms pre-stimulus baseline. Trials contaminated by artifacts, in which the EEG and EOG exceeded ±100 μV, were rejected (Semlitsch, Anderer, Schuster, & Presslich, 1986; Average trial % rejected as artifact-contaminated =4.0%).

We focused onanalyzing the ERPs that happy and fearful faces elicited. The average ERP epoch was 1300 ms, including a 200 ms prestimulus baseline. We measured component amplitude and latencies relative to the 200 ms prestimulus baseline and derived peak amplitudes from baseline-to-peak measurements using an automated system. The P1 was defined at O1 andO2 as the peak activity between 100 and 200 ms post-stimulus, and the LPP was defined at F3, F4, C3, C4, P3, and P4 as the peak activity between 400 and 700 ms post-stimulus.

Repeated-measure analyses of variance (ANOVAs) were performed on the behavioral and ERP data. Specifically, we chose only two intensity levels (75% and 100%), because most participants had difficulty in categorizing faces of 25% and 50% emotional intensity (error rate=59.39%). We evaluated reaction times and ERP measures from correct trials only (Mean % of trials used in analyses=89.64%).

Results

Correlation between behavioral measures and ERP data

We performed Pearson correlation between behavioral measurements (reaction times and correct identification rates) and ERP data (P1 latency & amplitude, LPP latency & amplitude for each emotion (neutral, happy, and fearful) or intensity (75% & 100%)) to assess the extent to which these two measures were correlated. In the PTSS experience group, only the P1 amplitude with the 100% intensity fearful face was significantly positively correlated with the response time for fearful emotional face stimuli (r=.542, p<.05). This suggests a greater allocation of attention to fearful faces, given that response to fearful faces was slower. No other correlative effects for behavioral and ERPs were significant (all p values>.1). On the other hand, in the control group, the P1 amplitude with the 75% intensity fearful face was negatively correlated with the accuracy rate(r=-.581, p< .05), and the LPP amplitude for the full intensity fearful face was negatively correlated with reaction time.

Behavioral Measures

For the within-subjects variables, we performed a mixed-design ANOVA on the mean reaction time and the rates of correct identification of face stimuli with both emotions (happy & fearful) and intensities (75% & 100%). We used the groups (two groups: PTSS experience & Control) as the between-subjects factors. Table 2 shows the mean RTs and accuracies. Accuracy showed a significant main

Table 2. Accuracy and RT measurement means

	PTSS experience group (n=15)		Control group (n=15)	
	M	SD	M	SD
Correct detection (% accuracy)				
Neutral face	82.0	19.9	92.1	7.9
RTs (ms)				
Neutral face	894.2	151.8	788.4	97.0
Correct detection (% accuracy)				
75% intensity for happy face	82.1	22.7	93.5	8.5
100% intensity for happy face	85.9	21.6	96.6	5.6
RTs (ms)				
75% intensity for happy face	839.8	184.7	710.0	75.3
100% intensity for happy face	783.7	164.9	665.4	74.0
Correct detection (% accuracy)				
75% intensity for fearful face	83.9	18.4	91.8	9.7
100% intensity for fearful face	87.1	15.3	96.1	7.8
RTs (ms)				
75% intensity for fearful face	863.5	157.8	765.5	69.8
100% intensity for fearful face	813.6	164.3	716.7	83.3

PTSS= post-traumatic stress symptom; RT= reaction time effect of intensity ($F(1,28)=19.96$, $p<.001$), indicating that accuracy increased as the intensity of emotional expression increased. We found a marginally-significant main effect of group ($F(1,28)=3.77$, $p=.06$). However, regarding the correct identification rates for the neutral faces, we found no significant differences between the groups. This indicates that individuals with PTSS could only weakly detect emotional facial expressions. In terms of RT, we found main effects of emotion ($F(1,28)=7.45$, $p<.05$) and group ($F(1,28)=6.18$, $p<.05$). Additionally, RTs for the neutral faces revealed significant differences between the groups ($t(28)=2.27$, $p<.05$). Therefore, not only did categorizing a fearful expression produce slower RTs than did categorizing a happy face, but individuals with PTSS also showed slower RTs when recognizing emotional faces including neutral faces than did control participants. The main effect of intensity also appeared as significant: the greater the emotional expression intensity, the faster participants detected the emotion ($F(1,28)=92.37$, $p<.001$). No other main or interaction effects for accuracy and RT were significant (all p values$>.27$).

ERPs

We also conducted a three-way repeated ANOVA on the amplitude and latency of each component, with emotion (two levels: happy & fearful), intensity (two levels: 75% & 100%) and group (two groups: PTSS experience & Control) as the between-subjects factors. We found no significant differences between the PTSS experience and Control groups in their processing of neutral faces (all p values$>.2$).

P1 component

Due to the analysis to examine rapid selective attention during facial expression processing via the P1 component, we found a significant main effect of group ($F_{(1,28)}=4.30$, $p<.05$) and emotion ($F_{(1,28)}=4.38$, $p<.05$) regarding P1 amplitudes. These results that indicated the experimental group increased their allocation of attention to facial expression cues than did the

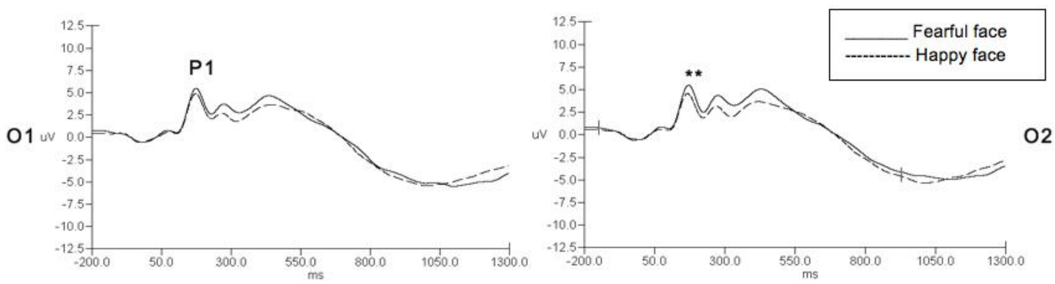

Figure 1. Grand average waveforms (n = 30) on P1 component for Fearful and Happy faces (**p < .05)

control group, and all participants showed greater P1 amplitude enhancements in response to fearful faces, as compared to happy faces (see Figure 1 and 2). In addition, an analysis of P1 latency revealed a significant main effect of emotion, indicating that fearful faces elicited longer latency (171.8 ms) than did happy ones (169.3 ms) ($F_{(1,28)}$=11.02, p<.05). No other main or interaction effects for the P1 component's amplitude or latency were significant

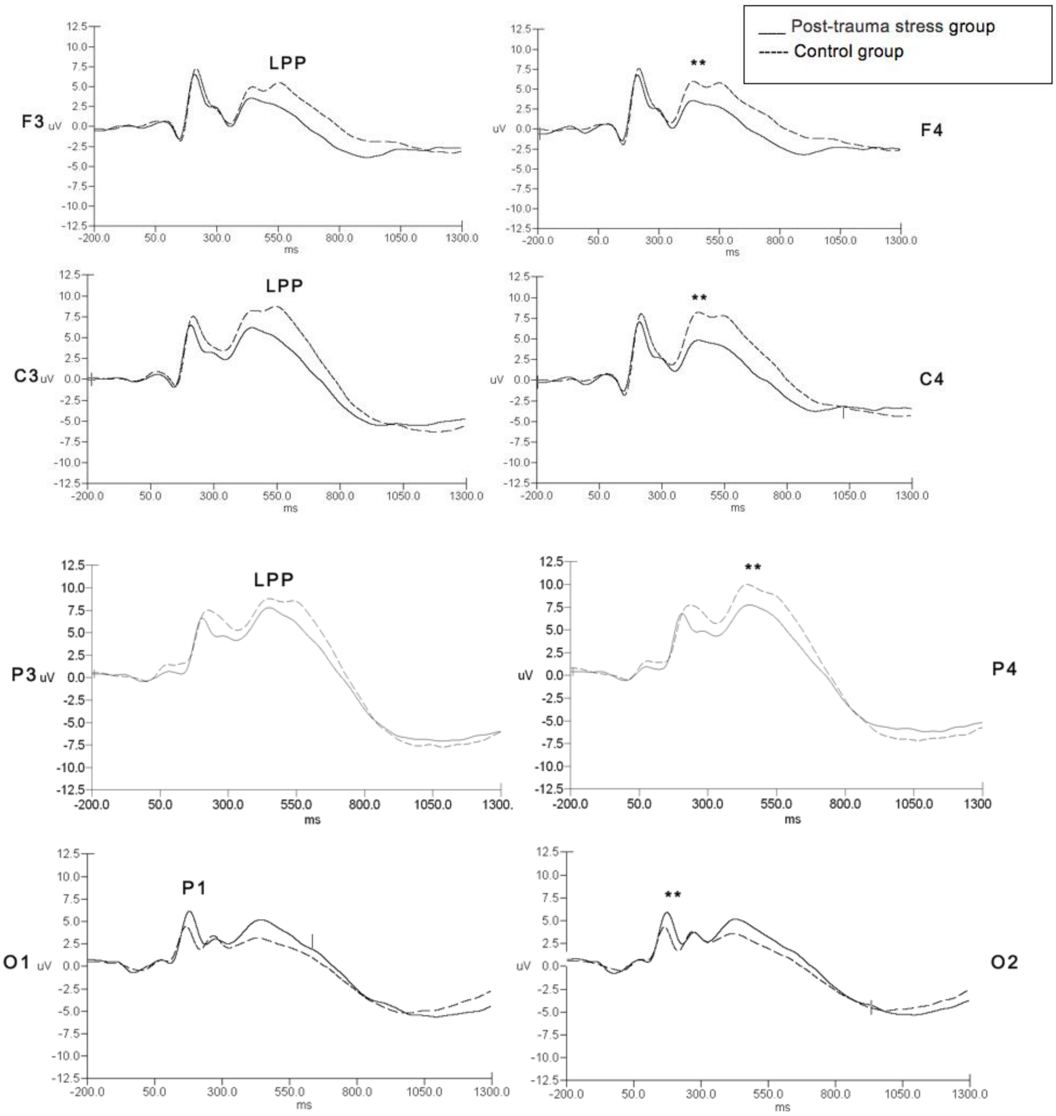

Figure 2. Grand average waveforms (n = 15) for the P1 & LPP components in the Post-traumatic stress symptom experience and Control groups (**p < .05)

(all p values>.08).

LPP component

As a result of the analysis examining later cognitive processing strategies, we found that LPP amplitude showed a significant main effect of group ($F(1,28)=5.54$, $p<.05$). This revealed that the control group generally showed larger LPP magnitudes than did the PTSS experience group. That is, the latter group had greater difficulty inprocessing detailed information about facial emotional stimuli as compared to the control group (see Table 3). Moreover, an analysis of LPP latency revealed a significant interaction between emotion and group ($F(1,28)=11.02$, $p<.05$). This interaction suggests that LPP latency was slower for fearful faces than it was for happy faces in the PTSS experience group, whereas LPP amplitude was faster for fearful faces than for happy faces in the control group. No other main or interaction effects for the LPP component's amplitude or latency were significant (all p values>.08).

Discussion

This study aimed to investigate the mechanisms involved in the processing of facial expressions by individuals with PTSS. We sought

Table 3. LPP amplitude means for electrode sites between groups

	PTSS experience group (n=15)		Control group (n=15)	
	M	SD	M	SD
Happy face				
F3	8.6	2.7	9.9	5.6
F4	7.8	3.1	10.9	6.1
C3	8.4	3.0	9.4	4.3
C4	8.0	4.3	11.4	5.0
P3	5.2	2.8	7.9	4.4
P4	5.1	2.4	7.2	4.8
Fearful face				
F3	8.1	3.0	8.6	2.9
F4	7.8	3.2	9.0	4.2
C3	7.6	2.8	8.9	3.6
C4	8.4	3.0	9.4	3.9
P3	9.9	3.1	10.0	3.9
P4	9.6	3.4	10.0	3.4

PTSS= post-traumatic stress symptom

to identify the processing stage during which abnormal facial expression processing occurs. To discern this, we compared ERPs elicited in response to differing facial expressions (fearful and happy) and emotional intensities (75% and 100%) according to participant group (PTSS experience group or control). Our major finding is that individuals with PTSD symptoms have an enhanced early P1 component and a diminished LPP component in response to all stimuli, as compared to control individuals.

As previously mentioned, the experimental group exhibited an enhanced visual P1 component as compared to the controls. Moreover, all participants showed greater P1 amplitude enhancements in response to fearful faces, as compared to happy ones. When we carried out a detailed inspection of results, this emotional effect was shown to be more prominent in the PTSS experience group, using a within–subjects ANOVA. Although these finding should be interpreted with due caution, the PTSS experience group's enhanced P1 in response to fearful facial expressions supports there being a neural basis to attentional vigilance to facial expressions, especially with regard to threat-related information, as observed in previous studies (Attias et al., 1996; Constans et al., 2004). The presence of occipital sources observed during 100-200 ms of P1 also suggests that the visual encoding of face stimuli thought to occur during this period is enhanced by fear-related valence. Thus, this interpretation was consistent with the hypothesis that early appraisal of potential danger may occur via a direct visual pathway, and that the amygdala's feedback to the visual cortical areas might trigger the greater attentional processing resources required to interpret emotionally salient stimuli (Amaral et al., 2003; Bar-Haim et al., 2005; Pessoa et al., 2002; Vuilleumier et al., 2004). Indeed, neuroimaging studies have revealed a reciprocal modulation between visual association areas and regions elicited preferentially by fear-related stimuli (Hariri et al., 2003). Preferential processing of threat-related information in PTSD, particularly in the form of attentional biases (Bar-Haim et al., 2007), may also occur because of heightened activation within an amygdala-based “threat evaluation system”, leading to disproportionate reaction to emotional stimuli.

In contrast to the enhanced P1 response to fearful expressions, a pattern of diminished ERP responses to both fearful and happy expressions appeared across the remaining ERP component in the PTSS experience group. The LPP, which reflects elaborate information processing, had a lower magnitude in the PTSS experience group than it did in the control group, regardless of the emotional expression participants viewed. This finding is consistent with the cognitive processing impairment that prior studies have suggested (McNally, 2006), which indicates that individuals with PTSS exhibit difficulty in sustaining attention or conscious evaluation of emotional content for the processing of facial expressions, relative to controls.

The present study investigated how individuals with PTSS process emotional facial expressions over time. The findings exhibit dissociation patterns among the processing stages, which is consistent with previous studies. The concept of dissociable two-stage processing may be supported by a cognitive model (Arnell & Jolicoeur, 1999; Chun & Potter, 1995). A brief, complete activation of stimulus information occurs in the first stage. Representations forming during this stage are subject to rapid decay or overwriting by subsequent information, unless they are selected for second-stage, elaborative processing. However, since the second stage is effort-intensive and capacity-limited, individuals with PTSS are unable to comprehensively process the facial expressions' conveyed information. We found the RTs and correct-emotion identification rates differed significantly between groups, indicating that individuals with post-traumatic stress responded to stimuli more slowly and made more errors than did their counterparts in the control group. This result is consistent with those of previous studies (Sta. Maria, 2002; Gapen, 2009). Therefore, it can be concluded that individuals with PTSS show abnormal facial expression processing, which reflects a lower ability to recognize facial expressions, and that this particular atypical processing occurs due to a cognitive processing deficit.

An additional factor we examined was the effect of emotional expression intensity on recognition. Facial expressions differ, not only by emotion type, but also in respect to saliency, that is the intensity of a particular emotion's display. Individuals with PTSS appear more sensitive to ambiguous, threat-related facial expressions than do controls (Masten et al., 2008). Although our ANOVAs revealed no intensity effects, the planned partial ANOVAs for each intensity level showed an interaction effect between emotion and group at 75% intensity ($F(1,28)=4.66$, $p<.05$). Moreover, when we performed additional planned partial ANOVA for the 50% intensity level to elucidate this effect, the result had a trend (not significant) for emotion x group in P1 amplitude ($F(1,28)=3.6$, $p=.058$). This indicates that the PTSS experience group paid more attention to ambiguous fearful expressions than they did to happy expressions, while the reverse was true for control participants. This finding is consistent with prior studies' findings that PTSD patients show more sensitivity to ambiguous, threat-related facial expressions than they do to non-threat-related facial expressions (Masten et al., 2008). In addition, our results were consistent, in part, with the results of previous studies that focused on how facial emotion intensity affects brain response (Sperengelmeyer & Jentzsch, 2006).

This study has some limitations. First, we did not use a clinician-administered measure to sort participants into PTSS experience and control groups. Although the PDS has a documented, sound diagnostic accuracy when compared to a clinician-administered interview (Foa et al., 1997), use of the Clinician Administered PTSD scale, or another clinician-administered measure, might have helped us to more accurately diagnose whether the participants' reported symptoms met DSM-Ⅳ PTSD criteria. Another limitation of the study is that participants with histories of traumas other than interpersonal violence were part of the control group. Although the present study did not reveal a significant difference within the control group according to trauma experience in the processing of emotional facial expressions, some previous studies have demonstrated that a previous traumatic experience, rather than PTSS, may influence emotional facial expression processing (Masten et al., 2008). Thus, future studies are needed to determine the proper categorization of participants who have experienced trauma and have PTSS, who have experienced trauma but lack PTSS, and who have not experienced trauma. Third, we used only correct responses (e.g., classification as ‘happy’ when a happy face was shown) as a measure for behavioral and ERP data. However, according to signal detection theory (Tanner, Wilson, John, & Sets, 1954) false responses may be equally or even more informative with regard to PTSD. Especially, because P1 amplitude and latency reflects automatic processing regardless of whether a response is correct, future studies should consider this issue. This study's final limitation is that several participants with PTSS had significant depression scores on the BDI, although the result of correlation between BDI score and behavioral & ERP data had no significant correlations except for neutral face accuracy (r=-.427), and P1 latency for the 75% intensity happy face (r=.417), leaving open the possibility that depressive symptomatology could have influenced our results. Moreover, it is unclear these results come from PTSS or generalized anxiety. Comorbidity rates between PTSD and other mood or anxiety disorders are strikingly high. By one estimate, in men with PTSD, the lifetime comorbidity with another DSM disorder is over 80% (Kessler et al., 1995). Thus, additional studies directly investigating depression's role in PTSD are warranted.

In conclusion, the present study investigated the temporal mechanisms by which individuals with PTSS process emotional facial expressions over time. The results indicate that, relative to controls, individuals with PTSS show heightened, rapid attention to, or detection of, emotional facial expressions, while they demonstrate overall cognitive deficits, including difficulty with sustained attention, in emotional facial expression processing. Therefore, this study's results have important implications for social-cognitive processing in PTSS. Developing an understanding of the mechanisms involved during emotional facial expression processing in PTSS may ultimately help inform therapeutic approaches, enabling individuals with PTSS to solve their social impairment by receiving training in cognitive abilities, including concentration on the task or other person involved.

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외상 후 스트레스 증상자의 정서적 얼굴표정 처리과정: 사건관련전위(ERP) 연구

이 유 선 이 장 한

중앙대학교 심리학과

본 연구는 외상 후 스트레스 증상(post-traumatic stress symptom: PTSS)을 경험한 사람이 보이는 정서적 얼굴표정 처리의 신경학적 기제와 그 세부적인 처리단계를 확인하고자 하였다. 실험은 PTSS 경험집단과 외상경험이 없는 통제집단을 대상으로 공포, 행복, 중성 얼굴표정을 확인하는 과제를 실시하였으며, 얼굴표정을 인식하는 데 걸리는 반응시간과 정확율, 그리고 사건관련 전위(ERPs)를 측정하였다. 연구결과, PTSS 경험집단이 통제집단에 비해 모든 정서적 얼굴표정을 인식하는데 느린 반응시간을 보였으며 반응도 부정확하였다. 또한, 사건관련 전위의 결과에서도 통제집단에 비해 PTSS 경험집단에서 자극에 대한 빠른 주의 및 탐색을 반영하는 초기 P1 전위는 증가된 반면, 자극에 대해 정교한 인지적 처리를 반영하는 후기 LPP 전위는 유의미하게 감소되었다. 이를 통해, PTSS 경험집단이 타인의 얼굴표정을 인식하는 데 어려움을 지니고 있으며, 이런 특징이 정보처리의 초기단계보다는 정교한 인지처리를 요구하는 후기단계에서 발생함을 확인할 수 있었다.

주요어 : 외상 후 스트레스 증상, 사회적 기능 이상, 얼굴 표정, 사건관련 전위