Neural Correlates of Levels of Emotional Awareness During Trauma Script-Imagery in Posttraumatic Stress Disorder

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Objective: To examine individual differences in levels of emotional awareness as a predictor of the blood oxygenation level dependent (BOLD) response to trauma script-driven imagery in trauma-exposed individuals with (n = 25) and without (n = 16) posttraumatic stress disorder (PTSD). **Methods:** Participants completed the Levels of Emotional Awareness Scale (LEAS) and a functional magnetic resonance imaging trauma script-driven imagery paradigm. **Results:** Patients with PTSD exhibited lower LEAS scores in comparison with the control group. LEAS scores correlated positively with BOLD activity during trauma script-imagery in the ventral anterior cingulate cortex (vACC) in healthy controls, whereas LEAS scores correlated negatively with activation of vACC in individuals with PTSD. **Conclusion:** Patients with PTSD exhibit lower than average levels of emotional awareness. Levels of emotional awareness are differentially associated with vACC response during trauma script-driven imagery in healthy controls versus individuals with PTSD. **Key words:** emotional awareness, alexithymia, posttraumatic stress disorder, script-driven imagery, anterior cingulate cortex, medial prefrontal cortex.

PTSD = posttraumatic stress disorder; **LEAS** = Levels of Emotional Awareness Scale; **vACC** = ventral anterior cingulate cortex; **dACC** = dorsal anterior cingulate cortex; **mPFC** = medial prefrontal cortex; **BA** = Brodmann Area; **DSM-IV** = Diagnostic and Statistical Manual—4th Edition; **BOLD** = blood oxygenation level dependent; **SVC** = small volume corrected; **fMRI** = functional magnetic resonance imaging.

INTRODUCTION

Individuals with posttraumatic stress disorder (PTSD) often exhibit symptoms of alexithymia, that is, difficulty when attempting to identify and label their affective experiences (for a meta-analysis, see work by Frewen et al., (1). Key roles for the ventral and dorsal regions of the anterior cingulate cortex (vACC and dACC; Brodmann Areas [BA] 24, 25, 32) have been documented in the neural processing that gives rise to emotional awareness and affective experience (2–8). For example, Lane and colleagues (9) observed that individuals with greater levels of emotional awareness exhibited greater activation in the dACC (BA 24) when attending to their affective experiences.

Studies of the neural correlates of traumatic memory reexperiencing in PTSD have consistently implicated decreased response within the dACC, vACC, and medial prefrontal cortex (mPFC; BA 10) (10,11). However, previous studies of PTSD symptom-provocation have typically not examined individual differences in emotional awareness within groups of subjects with PTSD in comparison with trauma-exposed healthy controls. Frewen and colleagues (12) recently demonstrated that PTSD patients with higher alexithymia showed increased response in the posterior cingulate cortex and right posterior insula, and decreased response in the vACC, right ventrolateral prefrontal cortex, and right anterior insula, among other regions, during traumatic memory recall. However, it is important to supplement subjective self-reports of alexithymic characteristics with objective measures of the subjects' ability to identify and label their emotional states (13,14).

Accordingly, for the present study, the same PTSD subjects completed the Levels of Emotional Awareness Scale (LEAS) (14) to objectively index individual differences in emotional awareness, particularly as described by Lane's and Schwartz's developmental-hierarchical model (15). This model posits that raw physiological sensations represent a basic level of emotional awareness that is modulated, re-represented, and refined at increasingly higher levels of linguistic conscious cognitive processing to a greater extent in individuals of higher emotional awareness-intelligence. This increased complexity in the conscious affective experience of self and other may, in turn, facilitate emotion regulation.

It was hypothesized that trauma-exposed nonpsychiatric control subjects would demonstrate greater levels of emotional awareness than would individuals with PTSD on the basis of previous studies of increased alexithymic characteristics in this population (1). It was further hypothesized that, within the healthy control group, increasing levels of emotional awareness would correlate with increasing blood oxygenation level dependent (BOLD) activity during trauma-script imagery in the anterior cingulate cortex (ACC) and mPFC on the basis of previous research (9, McRae et al., *Neuroimage*, submitted). The neural correlates of LEAS scores with activation of the same structures were also examined in subjects with PTSD.

The Health Sciences Research Ethics Board of the University of Western Ontario approved the present study. Data were collected between October 2003 to October 2005.

METHODS

Participants

Two groups of subjects were studied, all of whom were determined to be right-handed: a) subjects with a current diagnosis of PTSD primarily due to a motor vehicle accident (n = 25, 18 females), none of whom were receiving psychiatric medications during this study; and b) subjects who met criterion A for PTSD (as a result of a motor vehicle accident) but who never met Diagnostic and Statistical Manual—4th Edition (DSM-IV) criteria for lifetime PTSD or any other DSM-IV diagnosis (n = 16, 9 females). Twenty-five of

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these participants were also described in a previous study investigating the Toronto Alexithymia Scale in PTSD (12).[1] Pertinent clinical and diagnostic information is documented in Table 1.

Levels of Emotional Awareness Scale (LEAS)

The LEAS (10-item version) (13) is a written performance measure that asks participants to describe their anticipated feelings and those of another person in each of 10 scenes (vignettes). Each scene is described in four or fewer sentences on separate pages, followed by two questions: "How would you feel?" and "How would the other person feel?" Participants answer these questions within the remaining space on the page. Standardized scoring criteria are used to evaluate the degree of differentiation and integration of the words used by participants to denote emotion attributed to self and other with higher scores indicative of higher emotional awareness.

Responses to each question for each scene are scored separately from 0 to 4, the numbers corresponding to the levels of emotional awareness outlined in Lane's and Schwartz's hierarchical model (15). A score of 0 is given for responses that involve only nonemotion words whereby the word "feel" is used to describe a thought rather than a feeling. A score of 1 is given when responses are deemed by raters to reflect an awareness of physiological cues (e.g., "I'd feel tired"), whereas a score of 2 is awarded when responses include words that are typically used to refer to relatively undifferentiated affective states (e.g., "I'd feel bad") or words that describe an action tendency such as: "I'd feel like punching the wall." A score of 3 is awarded when responses involve use of one word conveying a typical, differentiated emotional state (e.g., happy, sad, angry) whereas a score of 4 is conferred when two or more differentiated emotional states are described that together convey a greater degree of emotional complexity than either word used alone. After the 0 to 4 scores are assigned for the response to the self and other related questions, a third "total" score is given which is equal to the higher of the two self and other scores, except in the case in which both self and other scores are 4s, in which case a total score of 5 is given if the emotions for self and other can be differentiated from one another. Only the results using the total score were analyzed for this study. A glossary of words is used to guide scoring. The protocols were coded independently of the others across all subjects by one expert rater who was blind to participants' diagnostic status. Interrater reliability of LEAS total scores has been consistently high (e.g., 13) in previous research. Although interrater reliability was not investigated in the present study, LEAS scoring was completed by an expert scorer. In addition to the standard scoring method, each of the LEAS responses was scored for adaptability. Specifically, blind raters ($n = 3$) each assigned a score from 0 to 2 indicating whether the response indicated an adaptive (0), somewhat maladaptive (1), or very maladaptive (2) response to the situation described (intraclass correlation coefficient between raters = 0.89); the average score between the three raters was used as the dependent measure.

Procedure

Participants completed standard diagnostic interviews (Structured Clinical Interview for DSM-IV and the Clinician Administered PTSD Scale) and the LEAS approximately 1 week before functional magnetic resonance imaging (fMRI) scanning. The script-driven imagery method is described previously (13) and exactly followed that used in published samples (e.g., 16). The method involved three repetitions of trauma and neutral scripts that each included a 30-second script listening phase followed by a 30-second script imagery phase, after which 120 seconds passed before the script was repeated.

Functional MRI Data Acquisition

All imaging data were acquired on a whole body magnetic resonance imaging (MRI) system (4 Tesla Varian UNITY^{INVOA}, Palo Alto, California) equipped with actively shielded gradient coils (Siemens Sonata, Erlangen, Germany). A cylindrical transmit-receive hybrid birdcage radio frequency head coil was used for transmission and detection of signal. The subject's head was immobilized with foam padding and a Plexiglas head cradle within the head coil. Preliminary T_1-weighted sagittal images were acquired using a fast low-angle shot (FLASH) inversion-recovery sequence (128 × 128 matrix size, field-of-view (FOV) = 28 cm, inversion time (TI) = 750 ms, echo time (TE) = 3.5 ms, repetition time (TR) = 8 ms, tip angle = 11°), which provided excellent gray/white matter contrast. From these localizer images, 12

[1]One PTSD subject did not complete the LEAS.

TABLE 1. Demographic and Clinical Variables

	PTSD (n = 25)	Control (n = 15)
Mean Clinician-Administered PTSD Scale Scores (SD)[a]	81.60 ± 23.47	4.29 ± 4.94
Time after trauma, in years (SD)[a]	6.11 ± 9.61	5.15 ± 7.79
Mean Toronto Alexithymia Scale – 20 Score (SD)[a]	58.24 ± 14.86	33.07 ± 7.22
Mean Beck Depression Inventory – II Score[a]	31.39 ± 11.99	5.00 ± 5.86
Mean Global Assessment of Functioning (SD)[a]	68.64 ± 12.85	98.57 ± 3.78
Gender (male:female)	7:18	6:9
Mean age (SD)	36.37 ± 12.83	38.25 ± 9.96
Ethnicity (n)		
White	24	15
Native Canadian	1	0
Marital Status		
Married or common-law (n)	10	6
Separated or divorced (n)	2	3
Single (n)	13	5
Highest level of education		
High school diploma or equivalency	6	3
University or college	15	9
Postgraduate	4	1
Employment status[a]		
Working full- or part-time	17	12
Unemployed	8	1
Annual income (n)		
<10,000	4	3
10,000–20,000	1	1
20,000–30,000	3	2
30,000–40,000	0	1
40,000–50,000	0	0
50,000–60,000	6	2
>60,000	0	1
Missing	11	5
Comorbid Axis I conditions[a]		
% Major depressive disorder	56	0
% Dysthymia	4	0
% Panic disorder with/without agoraphobia	12	0
% Generalized anxiety disorder	12	0

PTSD = posttraumatic stress disorder; SD = standard deviation.
Diagnostic and Statistical Manual of Mental Disorders—4th Edition (DSM-IV) disorders not listed were not present in the sample.
There was no medical or neurological morbidity associated with past drug or alcohol use in subjects with a history of substance abuse as assessed by interview. All PTSD subjects who were receiving medications (n = 16, 69%) had undergone a supervised drug washout for at least 2 weeks before scanning, and none were receiving fluoxetine before the drug washout; none of the control subjects were receiving psychiatric medications. Subjects with a history of psychosis, bipolar disorder, and substance use disorder in remission for <6 months were excluded from the study, as were patients with any significant medical conditions, neurological illness, or a history of head injury involving loss of consciousness as assessed by interview.
[a] Significant group difference.

contiguous functional planes were prescribed with an axial orientation approximately parallel to the anterior commissure-posterior commissure line (centered on a plane level with the anterior cingulate cortex) and a 6-mm slice thickness. A constrained, three-dimensional phase shimming procedure (17) was performed to optimize the magnetic field homogeneity over the prescribed functional volume. During each functional task, blood oxygenation level dependent (BOLD)-sensitive images were collected using a navigator-corrected four segment echo planar imaging sequence (128 × 128 matrix size, FOV = 22 cm, TE = 10 ms, TR=1250 ms, flip angle = 40°, 108 volumes, volume collection time = 5 sec). For registration of the BOLD sensitive images, a high-resolution T_1-weighted anatomic reference volume was acquired with the same axial FOV using a three-dimensional FLASH sequence (256 × 256 × 64 matrix size, slice thickness = 3 mm, TI = 600 ms, TE = 5.5 ms, TR = 10 ms, flip angle = 11°).

Statistical Analyses

Subjects' LEAS scores and LEAS "adaptiveness" scores were compared between groups using *t* tests. Analyses are based on brain activation occurring during the 30-second script imagery phase, comparing responses with trauma versus neutral scripts. The resulting statistical maps were then correlated with participants' LEAS scores separately within the control and PTSD groups. These group-level maps were, in turn, compared between groups using *t* tests to ascertain regions where correlations with LEAS scores were larger in the control group relative to the PTSD group, and vice versa.

Correlations with BOLD-neural response focused a priori on activation in ACC and mPFC. The presence of positive and negative correlates of LEAS scores in trauma-exposed controls and PTSD subjects within ACC and mPFC were identified in a random-effects model with a minimum cluster-extent of $k \geq 50$ voxels and $\alpha < 0.05$ (two-tailed) corresponding to a minimum $r \geq 0.39$ in the PTSD group and a minimum $r \geq 0.50$ in the control group (*r* critical values differ between groups due to differences in sample size). These clusters were considered statistically significant, however, only if they contained voxels that survived correction for multiple comparisons for a 5-mm spherical search volume centered at the identified voxel (small volume corrected [SVC] with $p < .05$ [referred to as p_{SVC}]; voxels were corrected for the false discovery rate within the spherical search volume).

RESULTS

LEAS Scores − Group Differences

Individuals with PTSD exhibited a lower mean ± standard deviation level of emotional awareness (32.8 ± 5.6) in comparison with controls (36.3 ± 4.5), t (35) = 1.90, p = .033. Individuals with PTSD also exhibited a significantly less adaptable response to the LEAS situations (26.0 ± 3.6) than did healthy controls (28.8 ± 1.3), t (35) = 3.43, $p < .001$.

LEAS Scores − fMRI Correlations in Controls

As predicted, increasing LEAS scores were associated with increasing BOLD response in the bilateral vACC (BA 24, 32) and mPFC (BA 10) within a cluster of 352 voxels with a maximum at: 8 54 to 2, $Z = 3.25$, $p < .001$ (p_{SVC} = 0.008). See Figure 1 left for illustration (the magnitude of the positive correlation is color bar coded as increasing from red to yellow).

LEAS Scores − fMRI Correlations in PTSD Subjects

In contrast, no areas within ACC or mPFC were found where LEAS scores correlated positively with BOLD response in PTSD subjects at the prespecified SVC-false discovery rate α level. LEAS scores were negatively correlated with BOLD activation within the vACC (BA 32–10) and mPFC (BA 10) in the PTSD group within a cluster of 201 voxels with a maximum at: 4 48 to 6, $Z = 3.04$, $p < .001$ (p_{SVC} = 0.010). See Figure 1 right for illustration (the magnitude of the negative correlation is color bar coded as increasing from blue to purple). In a supplementary analysis, these correlations

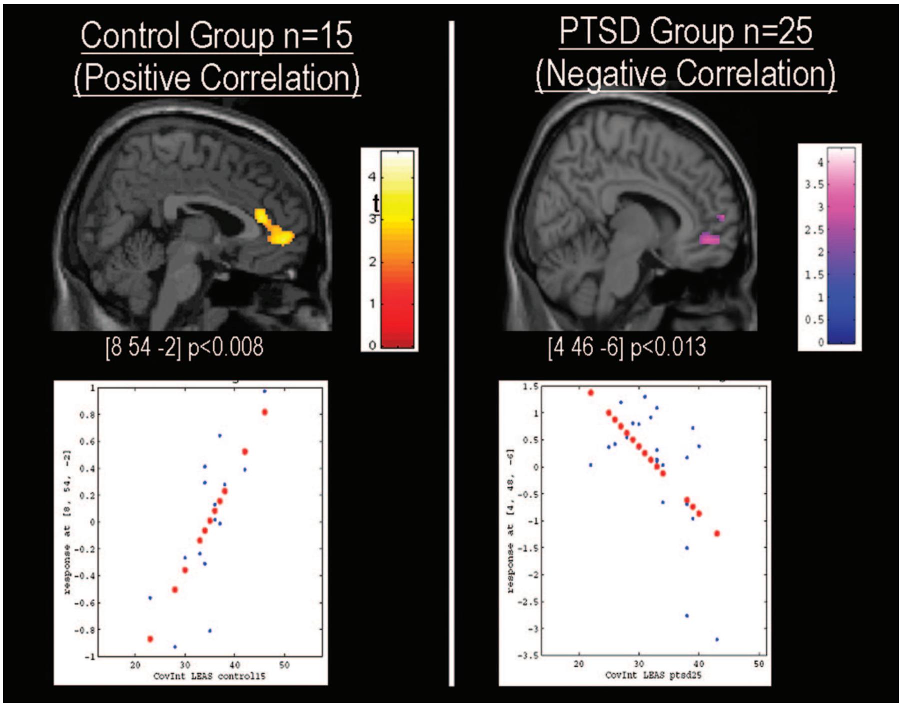

Figure 1. Positive and negative correlations of Levels of Emotional Awareness Scale (LEAS) scores with activation in the anterior cingulate/medial prefrontal cortex. $p < .05$ (2-tailed), $k \geq 50$. Participants' LEAS scores were regressed on their images of the contrast Trauma Script Imagery – Neutral Script Imagery in a random effects model. The color bar denotes the *t* statistic of the significance of *r*.

remained significant after covarying for Beck Depression Inventory II scores (data not shown).

LEAS Scores − fMRI Group Comparison

In a direct statistical comparison of group differences in the magnitude of correlations between LEAS scores and BOLD activity during traumatic- relative to neutral script-imagery, it was confirmed that the trauma-exposed controls more significantly activated ACC (BA 24, 32) and mPFC (BA 10) regions as a function of increasing LEAS scores in comparison with PTSD subjects within a cluster of 620 voxels with a maximum at: 2, 50, 6, $Z = 3.40$, $p < .001$ ($p_{SVC} = 0.003$).

DISCUSSION

The present results demonstrate lower levels of emotional awareness and emotional adaptability in individuals with PTSD relative to healthy nonpsychiatric controls during everyday (nontraumatic) social-emotional events and support previous findings of increased prevalence of alexithymic characteristics in the PTSD population (1). Moreover, distinctive neural correlates of LEAS scores were found in the healthy controls in comparison with individuals with PTSD. In the control group, increasing levels of emotional awareness were associated with increasing BOLD response, as hypothesized, in a cluster encompassing the vACC and the ventromedial prefrontal cortex. In stark contrast, LEAS scores were negatively correlated with BOLD response in a similar (more inferior) vACC-vmPFC cluster within individuals with PTSD. Importantly, we previously reported that in the same PTSD sample Toronto Alexithymia Scores were negatively correlated with vACC activation (maximum at 4 34 10) (12). Provided that TAS-20 scores are typically found to be correlated negatively with LEAS scores (e.g., 13), the finding that both scales correlated negatively with activation of the vACC requires explanation.

One interpretation is that, in certain cases, high TAS-20 scores are associated with less adaptive LEAS responses that nevertheless are demonstrative of high levels of emotional awareness. For example, in response to imagining receiving a back rub from a loving partner after a hard day at work (one of the LEAS items), one PTSD subject responded that she "would feel totally uncomfortable . . . [and] begin to withdraw inside. I would feel incredible shame at being touched . . . " As a result of such marked dysphoric reactivity, the subject received the third highest LEAS score coded in this study despite receiving the lowest adaptiveness score. Thus, in cases of extreme negative emotional response, high levels of emotional awareness may not always be adaptive. Another possibility is that some subjects who are very low in emotional awareness and thus score low on the LEAS may not be aware of their own alexithymia and thus score low on the TAS-20. Such complexities are consistent with Lundh and associates' observation of distinct subgroups of alexithymic individuals (as defined by the Toronto Alexithymia Scale) scoring at both the lower and upper extremes of the LEAS (18). It may therefore be important to consider both the level of emotional awareness and general adaptiveness of individuals' emotional responses to events in individuals with psychopathology.

Limitations of the present study include that state levels of emotional awareness were not measured (i.e., levels of emotional awareness in response to the trauma script-driven imagery paradigm itself), psychophysiological (e.g., heart rate) responses to the trauma script-driven imagery were not available, and the intrarater and interrater reliability of the scoring of LEAS responses was not evaluated. Furthermore, small sample sizes were employed, and psychiatric comorbidity within the PTSD sample was not controlled. It is also important to note that the present design is not able to address whether the BOLD responses measured reflect neuronal excitatory versus inhibitory processes. The role that psychological trauma history and disturbances in emotional awareness may play in determining functional connectivity between emotion-related brain structures, such as between amygdala and vACC (19) and right ventrolateral prefrontal cortex (20), are important areas for future research.

In conclusion, the present results suggest that individuals with PTSD on average exhibit low levels of emotional awareness and a low adaptability to everyday (nontraumatic) emotional situations. On a neurobiological level, individual differences in levels of emotional awareness may correspond with the efficiency of function of vACC-mPFC circuitry during emotion-stress challenges, such as exposure to reminders of a traumatic experience. Future studies are required to assess the reliability and generalizability of the present findings to fMRI probes of nontraumatic emotional imagery as well as to real life as opposed to imagined emotional encounters.

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