Emotional Numbing in Posttraumatic Stress Disorder: A Functional Magnetic Resonance Imaging Study

Paul A. Frewen, PhD; David J. A. Dozois, PhD; Richard W. J. Neufeld, PhD; Richard D. Lane, MD, PhD; Maria Densmore, BSc; Todd K. Stevens, PhD; and Ruth A. Lanius, MD, PhD

ABSTRACT

Objective: To explore the functional neural correlates of emotional numbing symptoms in individuals with posttraumatic stress disorder (PTSD).

Method: The study was conducted between September 2006 and June 2008 at the University of Western Ontario. Women with (n = 14) and without (n = 16) PTSD (based on *DSM-IV* criteria) completed a standardized emotional imagery task while undergoing functional magnetic resonance imaging, in addition to an assessment for emotional numbing symptoms. The study design was correlational, with primary outcome measures being blood oxygenation level–dependent (BOLD) response to emotional imagery task and self-reported severity of emotional numbing symptoms. Women without PTSD were not trauma exposed.

Results: In women with PTSD, emotional numbing symptoms predicted less positive affect in response to positive-valence scripts ($P < .05$) and less BOLD response within the dorsomedial prefrontal cortex during imagery of positive and negative scripts that were explicitly socially relevant ($P < .001$). In contrast, in women without PTSD, emotional numbing symptoms, while unrelated to subjective emotional responses, predicted greater response within the ventromedial prefrontal cortex during positive and negative scripts, in addition to scripts that elicited fear anxiety by nonsocial means (all P values < .001). The findings could not be attributed to dysphoria.

Conclusions: These findings are consistent with previous research regarding emotional numbing and emotional awareness. Less response within the medial prefrontal cortex during emotional imagery in individuals with high emotional numbing may indicate deficient conscious and reflective emotional processing. Further study is required to elucidate associations between state and trait emotional numbing and the neural correlates of psychological treatments specific to emotional numbing.

J Clin Psychiatry 2012;73(4):431–436

Submitted: *August 5, 2010; accepted February 18, 2011.*
Online ahead of print: *November 1, 2011 (doi:10.4088/JCP.10m06477).*
Corresponding author: *Paul A. Frewen, PhD, University of Western Ontario, Departments of Psychiatry and Psychology, University Hospital (Rm A10-222), 339 Windmere Rd, London, Ontario, Canada N6A 4G5 (pfrewen@uwo.ca).*

Symptoms of emotional numbing include the feeling of being emotionally numb, in addition to the *DSM-IV* posttraumatic stress disorder (PTSD) symptoms of anhedonia, social estrangement, and believing that one's life will somehow be cut short. Such symptoms have long been recognized in chronically traumatized subjects[1–3] and represent negative prognostic indicators for psychological treatment of PTSD.[4,5] Emotional numbing symptoms may also represent more specific indicators of psychopathology following traumatic events in comparison with reexperiencing and hyperarousal symptoms.[6] Despite their centrality to PTSD symptomatology, however, studies have not investigated individual differences in trait emotional numbing as a unique predictor of neural response to PTSD symptom provocation via script-driven trauma imagery.

In the present study, we investigated two hypotheses. First, provided that previous results suggested that emotional numbing symptoms may be particularly associated with anhedonia[7–10] and that anhedonic symptoms are increasingly noted in PTSD,[11,12] we predicted that emotional numbing symptoms would be particularly associated with response to positive-relative to negative-valence scripts. Second, provided that many of the *DSM-IV* emotional numbing symptoms are explicitly social in nature (eg, entailing perceived social estrangement and feeling "different" from other people)[13,14] and that the presence versus absence of social contextual factors significantly influences the neuropsychological processes mediating emotional responding,[15] we predicted that emotional numbing symptoms would be particularly associated with response to emotional stimuli that are distinctly social in nature. In order to examine these hypotheses, we utilized a paradigm that contrasted the independent effects of emotional valence and social relevance during emotional imagery.[16,17]

Finally, since the emotional numbing construct theoretically relates directly to that component of emotional processing for which we are consciously aware,[18] we hypothesized that emotional numbing symptoms would correlate negatively with response within dorsomedial prefrontal cortex in women with PTSD, because the dorsomedial prefrontal cortex has a recognized role in mediating conscious emotional processing.[19–21] We also investigated response within other brain regions previously associated with PTSD, specifically the ventromedial prefrontal cortex, bilateral amygdala, right insula,[22] and striatum.[7] Additional examination of emotional numbing symptoms in nonpsychiatric controls, following a dimensional model of emotional numbing symptomatology, was exploratory.

METHOD

Participants

All participants were recruited via community and hospital advertisement. Fourteen women with current chronic PTSD predominantly due to maltreatment experiences occurring during childhood took part. Diagnosis of PTSD was established by administering the Clinician-Administered PTSD Scale (CAPS),[23] comorbid diagnoses via the Structured Clinical Interview for *DSM-IV* Axis I Disorders (SCID-I),[24] and childhood maltreatment history by

Clinical Points

- Many women with posttraumatic stress disorder (PTSD) experience a feeling of being emotionally numb.
- Emotional numbing symptoms correlate with reduced dorsomedial prefrontal response during emotional processing, particularly during imagery of positive and negative social events.
- Provided that current psychological treatments for PTSD are largely directed toward reexperiencing and avoidance symptoms, increased attention toward treatments for emotional numbing symptoms may be indicated.

using the Childhood Trauma Questionnaire-Short Form.[25] Exclusion criteria included lifetime history of significant head injury, psychotic disorder, or bipolar disorder; alcohol or substance abuse; and use of psychotropic medications within the last 6 months. Sixteen women who did not have PTSD or any other psychiatric disorder and who had scores on the Childhood Trauma Questionnaire-Short Form within the normal range served as controls. The study was approved by the Health Sciences Research Ethics Board at the University of Western Ontario and participants provided written, informed consent to participate. The study was conducted between September 2006 and June 2008. Descriptive information is reported in Table 1.

Table 1. Demographic and Diagnostic Information for 14 Subjects With Posttraumatic Stress Disorder (PTSD)

Demographic	Value
Female, %	100
Age, mean (SD), y	37.22 (7.00)
Employed full or part time, % (n)	36 (5)
Severity of PTSD	
CAPS score, mean (SD), range	73.43 (12.02), 51–97
Severity of child maltreatment history	
CTQ score	
Emotional abuse, mean (SD)	20.75 (4.85)
In severe range, % (n)[a]	86 (12)
Physical abuse, mean (SD)	15.00 (5.58)
In severe range, % (n)[a]	57 (8)
Sexual abuse, mean (SD)	16.67 (8.99)
In severe range, % (n)[a]	50 (7)
Emotional neglect, mean (SD)	17.42 (4.68)
In severe range, % (n)[a]	50 (7)
Physical neglect, mean (SD)	12.67 (5.16)
In severe range, % (n)[a]	14 (2)
Current comorbid Axis I condition, n[b]	
Major depressive disorder	4
Dysthymia	2
Panic disorder with/without agoraphobia	1
Agoraphobia without panic disorder	1
Social phobia	1
Specific phobia	3
Obsessive-compulsive disorder	1
Generalized anxiety disorder	1
Undifferentiated somatoform disorder	3
Pain disorder	1
Hypochondriasis	1

[a]Severe range for CTQ cutoff scores from Appendix B in Bernstein and Fink.[25]
[b]*DSM-IV* disorders not listed were not present in the sample.
Abbreviations: CAPS = Clinician-Administered PTSD Scale, CTQ = Childhood Trauma Questionnaire.

Materials

Few psychometrically validated measures of emotional numbing have been published, and existing measures differ significantly in how they conceptualize and operationalize emotional numbing.[11,26] To measure emotional numbing symptomatology, we therefore asked participants to rate on a scale from 0 ("not at all or never") to 10 ("completely or very frequently") how often they had felt (1) "emotionally 'numb,' as if you *can't* experience emotions or feelings?" (2) "like your emotions and feelings are 'frozen,' 'sedated,' or 'numbed out,' so that you can't physically *sense* them?" (3) "'shut down' in an emotional sense, as if your emotional feelings have been 'turned off' or 'tuned out' in your body?" and (4) "'cut off' from your emotions and feelings, so that you can't *physically feel* them, even if you try?" We then averaged their response to the 4 questions. These items had demonstrated high internal consistency reliability as a scale ($\alpha = .91$), correlated positively ($r = 0.35$, $P = .01$) with scores on the Toronto Alexithymia Scale,[27] and differentiated women with versus those without PTSD in a conjointly conducted behavioral study (41 women with PTSD and 22 women without PTSD who completed the emotional imagery task described below outside of the functional magnetic resonance imaging environment; see Frewen et al[17]). In the present sample, the correlation between emotional numbing symptoms and the Toronto Alexithymia Scale was $r = 0.81$, $P < .001$. To evaluate discriminant validity, we assessed depressive symptoms via the Depression Anxiety Stress Scale Short-form–depression subscale.[28,29]

Behavioral Task Description

Affective Response Test-Negative and -Positive Versions. Primary results for the Affective Response Test-Negative and -Positive have been described in previous reports.[16,17] In brief, these tests involve listening to and imagining twenty-four 30-second audio-scripted vignettes happening to oneself, half of which generally elicit emotional experiences of moderate or stronger intensity (6 negatively valenced and 6 positively valenced), whereas the remaining are comparably neutral. The scripts were counterbalanced along the dimension of social versus nonsocial focus/relevance.[16,17] In the negative-valence version (the Affective Response Test-Negative), the 3 social scripts involved themes of social rejection and/or criticism, whereas the 3 nonsocial scripts tended to elicit fear or anxiety via nonsocial situations (eg, drowning). In the positive-valence version (the Affective Response Test-Positive), the 3 social scripts induced positive affect via interpersonal means (receipt of another's warm greeting, affection, or praise), whereas for the nonsocial scripts sensory-physical "relaxation" descriptions were used (eg, quiet walk on beach shoreline). Participants imagined that the vignettes were occurring and attended to their emotional responses. Afterward, they rated their emotional response from "no increase in emotion" to "felt strongly or very strongly" (scored 0 to 3) on items descriptive of positive and negative valence. Participants listened to 3 scripts of the same type in sequence,

each block of 3 scripts lasting 7 minutes and 21 seconds, partitioned among 3 repetitions of the following events: 30-second closed-eye baseline, 30-second closed-eye script imagery, 12-second closed-eye silent imagery, 7.5-second open eye baseline, 67.5-second open eye self-report question period. Between functional scans, participants were able to ask questions. The order of administration of the Affective Response Test-Negative and -Positive was counterbalanced and the order of administration of the distinct script types within the Affective Response Test-Negative and -Positive was randomized across participants.

Imaging Description

All imaging data were collected on a 4 Tesla Varian ^{UNITY}INOVA whole body scanner (Varian Inc, Palo Alto, California) equipped with Siemens Sonata gradients and a quadrature hybrid birdcage radio-frequency head coil. Preliminary scout images were collected and used to prescribe 25 contiguous 5-mm thick imaging planes from which functional data were acquired. The BOLD images were acquired with an interleaved, 2-segment gradient echo pulse sequence with spiraled gradient waveforms (field of view = 22 cm, 64 × 64 matrix size, repetition time = 1.5 seconds, echo time = 15 milliseconds, volume acquisition time = 3 seconds, flip angle = 60°). For anatomic registration, high resolution T1-weighted images were acquired with a 3-D gradient echo pulse sequence with spiraled gradient waveforms (256 × 256 matrix size, 64 × 2.5 mm slices, repetition time = 50 milliseconds, echo time = 3 milliseconds, inversion time = 1,300 milliseconds, flip angle = 20°).

Statistical Analyses

We used Statistical Parametric Mapping, version 2 (Wellcome Department of Cognitive Neurology, Institute of Neurology, London, England), to preprocess data using standard methods (all scans realigned to first volume, smoothing kernel of 8 mm). The BOLD response occurring during the 30-second script-listening period was contrasted with the 30-second baseline immediately preceding script onsets after convultion with the standard hemodynamic (γ) response function as applied by SPM2. Results are presented as random effects. Voxels were accepted as significantly correlated with emotional numbing score if they were contained within a cluster with an extent threshold of 10 that survived small-volume correction within spherical regions of interest (radius = 10 mm; familywise error [FWE] rate, $P_{FWE} < .05$; radius = 5 mm for amygdala only), as defined a priori by the Etkin and Wager meta-analysis[22]—dorsomedial prefrontal cortex (−12, +50, +20; +18, +52, +22; +12, +46, +22), ventromedial prefrontal cortex (+2, +38, −14), right amygdala (+26, +2, −28), left amygdala (−18, −2, −28), and right insula (+44, −6, +18)—or if they occurred within the striatum as defined structurally (nucleus accumbens, caudate, and putamen[2]). Thus, emotional numbing scores were additional regressors of response in the model, and investigations were conducted separately for each of the 4 valence-by-social script types. Note that at an uncorrected $P < .005$ level, the threshold for significance is $r \geq 0.66$. Results are also reported only if they also survived a partial correlation analysis covarying for depressive symptoms (Depression Anxiety Stress Scale Short-form–depression subscale scores).[28,29] Between-group comparisons of the significance of correlations were also investigated. Finally, please note that ancillary exploratory whole-brain analyses (with whole-brain correction for multiple comparisons) failed to identify additional areas of correlated response outside the aforementioned regions of interest.

RESULTS

Self-Report

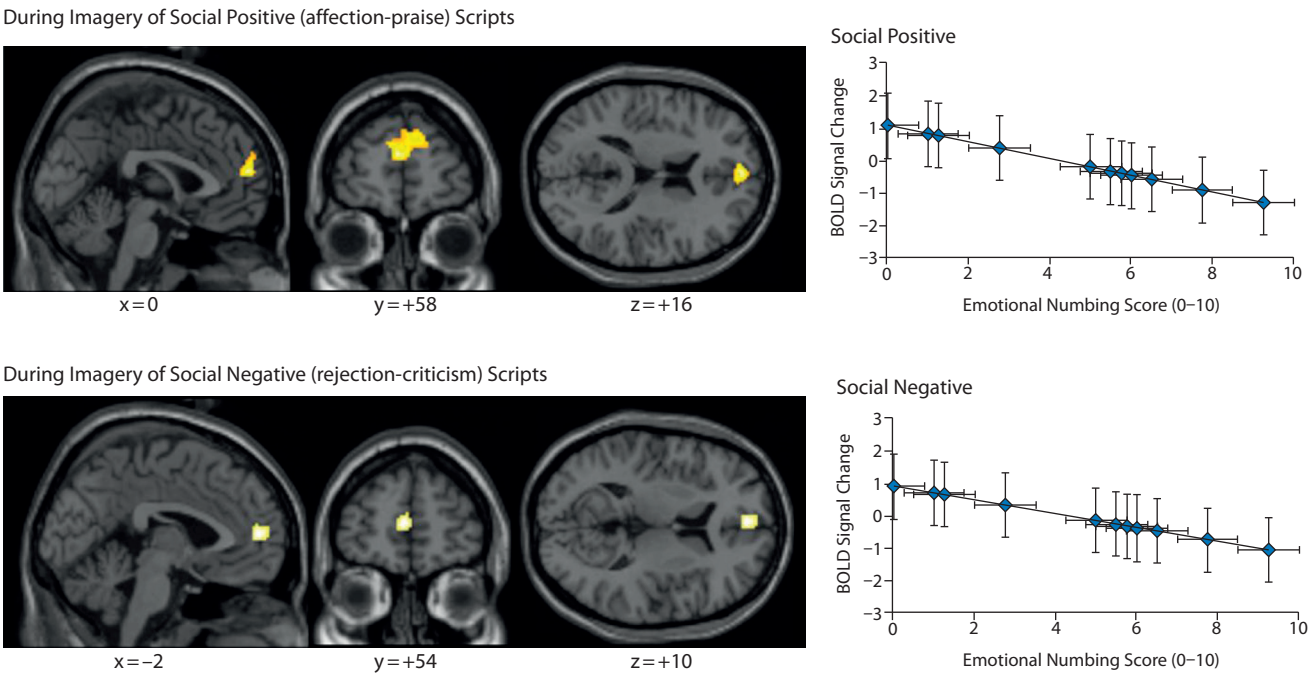
In women with PTSD, emotional numbing scores ranged from 0.00 to 9.25 (mean = 3.63, SD = 2.92). As predicted, emotional numbing scores were significantly lower in women without PTSD, ranging from 0 to 1.5 (11 of the 15 women had scores of 0, mean = 0.20, SD = 0.45; $t_{26} = 5.31$, $P < .0001$). In women with PTSD, emotional numbing scores were significantly negatively correlated with self-reported positive social and nonsocial emotional responses to the Affective Response Test-Positive ($r_{13} = -0.62$, $P < .05$). No corresponding associations were observed for negative emotional responses during the Affective Response Test-Negative or -Positive in women with PTSD. Emotional numbing symptoms were not significantly correlated with emotional response ratings in the control group for either the Affective Response Test-Positive or -Negative. Emotional numbing symptoms were not significantly correlated with Depression Anxiety Stress Scale Short-form–depression subscale scores in either group.

Imaging

As predicted, in women with PTSD, emotional numbing symptoms were negatively correlated with BOLD response in the dorsomedial prefrontal cortex during imagery of positive social scripts (ie, affection-praise: Montreal Neurological Institute [MNI] coordinates +12, +62, +36; cluster size [k] = 324; $r_{12} = -0.83$, $P < .001$) and negative social scripts (ie, rejection-criticism: MNI coordinates −2, +54, +10; k = 132; $r_{12} = -0.74$, $P < .001$) (Figure 1). No association with dorsomedial prefrontal cortex response was observed during imagery of nonsocial positive (relaxation) or negative (fear-anxiety) scripts. No associations were observed between emotional numbing symptoms and BOLD response within the ventromedial prefrontal cortex, amygdala, insula, or striatum for any script-type after controlling for depressive symptoms in women with PTSD.

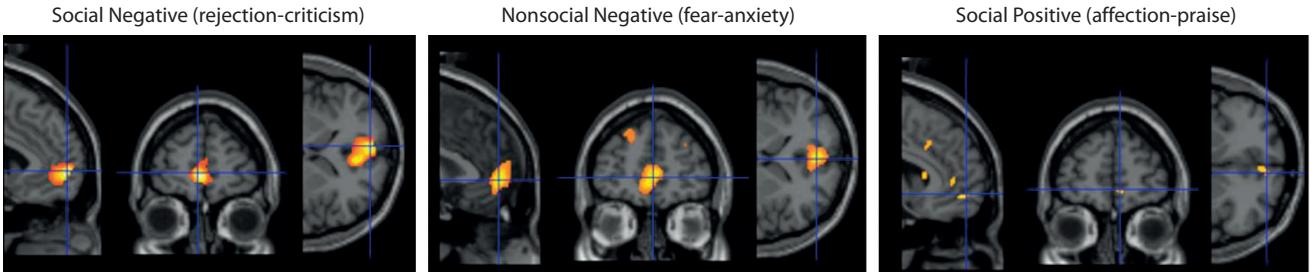
Strikingly, in women without PTSD, emotional numbing symptoms were associated with greater response in the ventromedial prefrontal cortex during imagery of negative nonsocial scripts (ie, fear-anxiety: MNI coordinates +2, +52, +0; k = 592; $r_{12} = 0.82$, $P < .001$), negative social scripts (ie, rejection-criticism: MNI coordinates −4, +58, 0; k=786; $r_{12} = 0.93$, $P < .001$), and positive social scripts (ie, affection-praise: MNI coordinates +8, +52, −8; k = 28; $r_{12} = 0.68$,

Figure 1. Decreasing Blood Oxygenation Level–Dependent (BOLD) Response Within Dorsomedial Prefrontal Cortex During Social Emotional Imagery in 14 Subjects With Posttraumatic Stress Disorder (PTSD) as a Function of Increasing Emotional Numbing Symptoms[a]



[a]The BOLD response in dorsomedial prefrontal cortex negatively correlates with emotional numbing symptoms in individuals with PTSD when imagining socially relevant, emotional scripts. Presented at $P < .05$ small volume correction.

Figure 2. Increasing Blood Oxygenation Level–Dependent (BOLD) Response Within Ventromedial Prefrontal Cortex During Emotional Imagery in 16 Control Subjects as a Function of Increasing Emotional Numbing Symptoms[a]



[a]The blood oxygenation level–dependent response in ventromedial prefrontal cortex positively correlates with emotional numbing symptoms in control subjects when imagining rejection criticism, fear-anxiety, and affection-praise scripts. Presented at $P < .05$ small volume correction.

$P < .001$). No significant effects were observed for imagery of positive nonsocial scripts (ie, relaxation) (Figure 2). Finally, no associations were observed between emotional numbing scores and BOLD response within the dorsomedial prefrontal cortex, amygdala, insula, or striatum for any script type in women without PTSD.

Between-group comparisons verified that emotional numbing symptoms were associated with greater response in the medial prefrontal cortex in the control group as compared with the PTSD group during imagery of fear-anxiety scripts (MNI coordinates +0, +54, +0; k = 398; $t_{25} = 5.24$, $P < .001$) and rejection-criticism scripts (MNI coordinates −6, +60, +0; k = 25; $t_{25} = 3.17$, $P = .002$). The group difference for response to positive social scripts did not reach statistical significance.

DISCUSSION

Emotional numbing symptoms represent a core affective disturbance associated with psychological traumatization,[3–5,11,26,30–32] although little is known concerning the biological bases of emotional numbing symptoms. Consistent with predictions, within women with PTSD, increasing emotional numbing symptoms predicted decreased response within the dorsomedial prefrontal cortex during imagery of positive and negative events that were explicitly social in nature.[9] Provided that response within the dorsomedial prefrontal cortex has been consistently observed with social cognition[33] and self-referential processing[34] tasks in addition to theory emphasizing a role for the dorsomedial prefrontal cortex, particularly in conscious emotional processing,[19–21]

these findings are consistent with a phenomenology of emotional numbing as involving a feeling of being emotionally numb (ie, deficits in the conscious processing of emotion,[18–21] including alexithymia[3,4,30,35]) as well as an interpersonal and existential disturbance.[3,4,26] In comparison, emotional numbing symptoms were associated only with self-reported, subjective, emotional responses during positive events in the direction of reduced positive affective experience. These findings are consistent with research emphasizing the anhedonic characteristics of emotional numbing.[11,31,32] Provided that current psychological treatments for PTSD are largely directed toward the reexperiencing and avoidance symptoms of the disorder and may be less effective in reducing emotional numbing, treatments specific to emotional numbing symptoms may be indicated.

Although reports of emotional numbing symptoms were largely specific to women with PTSD, a limited experience of emotional numbing was reported in a minority of control subjects. Such responses failed to correlate with depressive symptoms and therefore may not be reducible to nonspecific mild dysphoric mood. Strikingly, emotional numbing symptoms in controls were strongly positively correlated with neural response to negative emotional imagery within the ventromedial prefrontal cortex, and, to a smaller extent, ventromedial prefrontal cortex response occurring during imagery of positive social events. As these results were not predicted and are based on a very limited experience of emotional numbing in the control group, in addition to not being significantly correlated with self-reported emotional response, we emphasize the need for independent replication. In contrast, emotional numbing symptoms were not associated with response in other regions of interest, including the insula or amygdala in individuals with PTSD or in controls; absence of a response within amygdala may be partly explained by the fact that this region responds more strongly to emotional tasks that direct attention toward external rather than internal stimuli.[36,37]

Limitations of this study deserve mention. The measure of emotional numbing symptoms we employed requires further validation studies, including comparison with other instruments.[11,26] Our sample size was also small and restricted to women with chronic childhood maltreatment–related PTSD; the generalization of our findings to men and other trauma types requires further investigation, and our failure to detect associations in other brain regions may have been partly due to low power. Furthermore, we could not employ a trauma-exposed non-PTSD group in order to control for trauma exposure since all of the individuals with similarly severe exposure to traumatic events during childhood that we surveyed exhibited either current or past psychiatric symptoms as a result of such experiences. This is problematic since studies have found that disturbances in emotional processing may not be distinctive of PTSD but instead accompany trauma exposure in the absence of symptoms.[38] In addition, we did not employ validated measures of anhedonia or dissociative symptoms and therefore cannot differentiate the effects of emotional numbing in comparison with anhedonia or dissociation in this study. Although clinical studies have found that emotional numbing symptoms independently predict PTSD status in comparison with symptoms of both anhedonia (eg, Ramirez et al[39]) and dissociation (eg, Feeny et al[40]), biological studies comparing emotional numbing with anhedonia and dissociation are needed in order to disambiguate these theoretical constructs. Future studies may address these limitations and examine trait emotional numbing as a predictor of state emotional numbing and the neural correlates of treatment outcomes for emotional numbing symptoms in PTSD.

Author affiliations: Departments of Psychology (Drs Frewen, Dozois, and Neufeld), Psychiatry (Drs Frewen, Dozois, Neufeld, and Lanius and Ms Densmore), Neuroscience (Drs Neufeld and Lanius), and Medical Biophysics (Dr Stevens), The University of Western Ontario; Imaging Research Laboratories, Robarts Research Institute (Dr Stevens), London, Ontario, Canada; and Department of Psychiatry, University of Arizona, Tucson, Arizona (Dr Lane).

Potential conflicts of interest: None reported.

Funding/support: This study was supported by a grant from the Canadian Institute for Health Research (#348179) and a Canada Graduate Scholarship from the Social Sciences and Humanities Research Council of Canada to Dr Frewen.

Acknowledgments: The authors give special thanks to Suzy Southwell; Stephanie Nevill, MSc; and Melody Chow, MSc, of the University of Western Ontario for their assistance with data collection and to the London Health Sciences Centre Traumatic Stress Service for their assistance in subject recruitment efforts. Mss Southwell, Nevill, and Chow have no conflicts of interest to report.

REFERENCES

1. King DW, Leskin GA, King LA, et al. Confirmatory factor analysis of the clinician-administered PTSD Scale: evidence for the dimensionality of posttraumatic stress disorder. *Psychol Assess*. 1998;10(2):90–96.
2. Elman I, Lowen S, Frederick BB, et al. Functional neuroimaging of reward circuitry responsivity to monetary gains and losses in posttraumatic stress disorder. *Biol Psychiatry*. 2009;66(12):1083–1090.
3. Krystal H. *Massive Psychic Trauma*. New York, NY: International University Press; 1968.
4. Krystal H, Krystal JH. *Integration and Self-Healing: Affect, Trauma, Alexithymia*. Hillsdale, NJ: Analytic Press; 1988.
5. van der Kolk BA, McFarlane AC. The black hole of trauma. In: van der Kolk BA, McFarlane AC, Weisaeth L, eds. *Traumatic Stress: the Effects of Overwhelming Experience on Mind, Body, and Society.* New York, NY: Guilford Press; 1996:3–23.
6. Ehlers A, Clark DM, Dunmore E, et al. Predicting response to exposure treatment in PTSD: the role of mental defeat and alienation. *J Trauma Stress*. 1998;11(3):457–471.
7. Jaycox LH, Foa EB, Morral AR. Influence of emotional engagement and habituation on exposure therapy for PTSD. *J Consult Clin Psychol*. 1998;66(1):185–192.
8. North CS, Suris AM, Davis M, et al. Toward validation of the diagnosis of posttraumatic stress disorder. *Am J Psychiatry*. 2009;166(1):34–41.
9. Elman I, Ariely D, Mazar N, et al. Probing reward function in post-traumatic stress disorder with beautiful facial images. *Psychiatry Res*. 2005;135(3):179–183.
10. Hopper JW, Pitman RK, Su Z, et al. Probing reward function in posttraumatic stress disorder: expectancy and satisfaction with monetary gains and losses. *J Psychiatr Res*. 2008;42(10):802–807.
11. Orsillo SM, Theodore-Oklota C, Luterek JA, et al. The development and psychometric evaluation of the emotional reactivity and numbing scale. *J Nerv Ment Dis*. 2007;195(10):830–836.
12. Kashdan TB, Elhai JD, Frueh BC. Anhedonia and emotional numbing in combat veterans with PTSD. *Behav Res Ther*. 2006;44(3):457–467.
13. Kashdan TB, Elhai JD, Frueh BC. Anhedonia, emotional numbing, and symptoms overreporting in male veterans with PTSD. *Pers Individ Dif*. 2007;43(4):725–735.
14. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition. Washington, DC: American Psychiatric Association; 1994.
15. Britton JC, Phan KL, Taylor SF, et al. Neural correlates of social and

 © Copyright 2011 Physicians Postgraduate Press, Inc.

nonsocial emotions: an fMRI study. *Neuroimage*. 2006;31(1):397–409.
16. Frewen PA, Dozois DJA, Neufeld RWJ, et al. Neuroimaging social emotional processing in women: fMRI study of script-driven imagery. *Soc Cogn Affect Neurosci*. 2010;6(3):375–392.
17. Frewen PA, Dozois DJA, Neufeld RWJ, et al. Social emotions and emotional valence during imagery in women with PTSD: affective and neural correlates. *Psychol Trauma*. 2010;2(2):145–157.
18. Lane RD, Ahern GL, Schwartz GE, et al. Is alexithymia the emotional equivalent of blindsight? *Biol Psychiatry*. 1997;42(9):834–844.
19. Kober H, Barrett LF, Joseph J, et al. Functional grouping and cortical-subcortical interactions in emotion: a meta-analysis of neuroimaging studies. *Neuroimage*. 2008;42(2):998–1031.
20. Mechias M-L, Etkin A, Kalisch R. A meta-analysis of instructed fear studies: implications for conscious appraisal of threat. *Neuroimage*. 2010;49(2):1760–1768.
21. Lane RD, McRae K. Neural substrates of conscious emotional experience: a cognitive-neuroscientific perspective. In: Beauregard M, ed. *Consciousness, Emotional Self-Regulation and the Brain*. Amsterdam, Netherlands: John Benjamins Publishing Company; 2004:87–112.
22. Etkin A, Wager TD. Functional neuroimaging of anxiety: a meta-analysis of emotional processing in PTSD, social anxiety disorder, and specific phobia. *Am J Psychiatry*. 2007;164(10):1476–1488.
23. Blake DD, Weathers FW, Nagy LM, et al. The development of a clinician-administered PTSD scale. *J Trauma Stress*. 1995;8(1):75–90.
24. First MB, Spitzer RL, Gibbon M, et al. *Structured Clinical Interview for* DSM-IV *Axis I Disorders-Patient Edition (SCID-I/P, Version 2.0)*. New York, NY: Biometrics Research; 1996.
25. Bernstein D, Fink L. *Childhood Trauma Questionnaire: A Retrospective Self-Report*. San Antonio, TX: Psychological Corporation; 1998.
26. Glover H, Ohlde C, Silver S, et al. The Numbing Scale: psychometric properties, a preliminary report. *Anxiety*. 1994;1(2):70–79.
27. Bagby RM, Parker JDA, Taylor GJ. The twenty-item Toronto Alexithymia Scale, 1: item selection and cross-validation of the factor structure. *J Psychosom Res*. 1994;38(1):23–32.
28. Antony MM, Bieling PJ, Cox BJ, et al. Psychometric properties of the 42-item and 21-item versions of the Depression Anxiety Stress Scales in clinical groups and a community sample. *Psychol Assess*. 1998;10(2):176–181.
29. Lovibond SH, Lovibond PF. *Manual for the Depression Anxiety Stress Scales*. 2nd ed. Sydney, Australia: Psychology Foundation of Australia; 1995.
30. Badura AS. Theoretical and empirical exploration of the similarities between emotional numbing in posttraumatic stress disorder and alexithymia. *J Anxiety Disord*. 2003;17(3):349–360.
31. Litz BT. Emotional numbing in combat-related post-traumatic stress disorder: a critical review and reformulation. *Clin Psychol Rev*. 1992;12(4):417–432.
32. Litz BT, Gray MJ. Emotional numbing in posttraumatic stress disorder: current and future research directions. *Aust N Z J Psychiatry*. 2002;36(2):198–204.
33. Van Overwalle F. Social cognition and the brain: a meta-analysis. *Hum Brain Mapp*. 2009;30(3):829–858.
34. van der Meer L, Costafreda S, Aleman A, et al. Self-reflection and the brain: a theoretical review and meta-analysis of neuroimaging studies with implications for schizophrenia. *Neurosci Biobehav Rev*. 2010;34(6):935–946.
35. Frewen PA, Lanius RA, Dozois DJA, et al. Clinical and neural correlates of alexithymia in posttraumatic stress disorder. *J Abnorm Psychol*. 2008;117(1):171–181.
36. Phan KL, Wager T, Taylor SF, et al. Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI. *Neuroimage*. 2002;16(2):331–348.
37. Lieberman MD. Social cognitive neuroscience: a review of core processes. *Annu Rev Psychol*. 2007;58(1):259–289.
38. Phan KL, Britton JC, Taylor SF, et al. Corticolimbic blood flow during nontraumatic emotional processing in posttraumatic stress disorder. *Arch Gen Psychiatry*. 2006;63(2):184–192.
39. Ramirez SM, Glover H, Ohlde C, et al. Relationship of numbing to alexithymia, apathy, and depression. *Psychol Rep*. 2001;88(1):189–200.
40. Feeny NC, Zoellner LA, Fitzgibbons LA, et al. Exploring the roles of emotional numbing, depression, and dissociation in PTSD. *J Trauma Stress*. 2000;13(3):489–498.