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# Neural Processes of Emotional Conflict Detection and Prediction of Posttraumatic Stress Disorder Symptom Clusters in Traumatic Injury Survivors

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***Objective:*** Given the prevalence and significant burden of posttraumatic stress disorder (PTSD), identifying early predictors of symptom development following trauma is critical. PTSD is a heterogeneous disorder comprised of distinct symptom clusters—reexperiencing, avoidance, negative mood, and hyperarousal—that contribute to the broad range of possible symptom profiles. Affective and attentional regulation processes, such as emotional conflict detection, are impaired in individuals with PTSD; however, the neural mechanisms underlying these alterations and their predictive utility for the development of PTSD symptoms remain unclear. ***Method:*** Traumatic injury survivors ($N = 49$) without traumatic brain injury were recruited from the emergency department of an urban, Level-1 trauma center. Within 1 month of trauma exposure, participants completed a well-characterized emotional conflict task during a functional magnetic resonance imaging scan. Participants returned 6-month later for a clinical assessment of PTSD symptoms. Using a region-of-interest mask derived from whole-brain voxelwise analyses during emotional conflict detection (vs. no emotional conflict detection) we examined whether differential neural activity predicted 6-month PTSD symptom cluster severity. ***Results:*** Greater activation of the right middle frontal gyrus during emotional conflict detection prospectively predicted lower PTSD avoidance symptom severity 6 months later (above and beyond the effects of self-reported baseline PTSD and depressive symptoms, previous traumatic life events, racial discrimination, age, sex, and injury severity). ***Conclusions:*** Neural processes of emotion conflict detection measured in the early aftermath of a potentially traumatic event are useful as predictors for the development of PTSD symptoms.

***Clinical Impact Statement***

Posttraumatic stress disorder (PTSD) is an exceedingly burdensome disorder at both the societal and individual levels; however, predicting who may be at risk of developing PTSD following a traumatic event remains poorly understood. We found that, in a sample of traumatic injury survivors without traumatic brain injury, neural activation during an emotional conflict task administered within 1 month of injury predicted the development of PTSD avoidance symptoms 6 months later. Results inform on the mechanisms that may lead to the development of specific PTSD symptoms.

*Keywords:* functional magnetic resonance imaging, posttraumatic stress disorder, emotion, affective processing, trauma

*Supplemental materials:* https://doi.org/10.1037/tra0001586.supp



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Twelve million adults in the United States suffer annually from posttraumatic stress disorder (PTSD; U.S. Department of Veterans Affairs, 2022) with a staggering $232.2 billion spent on treatment (Davis et al., 2022). Although demographic, clinical, and biological factors of PTSD severity continue to be a focal area of research, comparatively little is known about risk factors for the development of the disorder. Indeed, most trauma survivors (nearly two-thirds) do not develop PTSD (Galatzer-Levy et al., 2018; U.S. Department of Veterans Affairs, 2022). Thus, research on early prediction of PTSD development after trauma is critical (Ziobrowski et al., 2021).

PTSD symptoms range from heightened physiological arousal and irritability (e.g., hyperarousal) to distancing oneself from emotional content (e.g., avoidance). Individuals with PTSD often struggle to match emotion to context, including difficulty in downregulating fear responses in instances of safety or upregulating feelings of pleasure in rewarding circumstances (Fitzgerald et al., 2018; Nawijn et al., 2015). Ability to filter emotional distractors (e.g., trauma reminders) is also particularly compromised (Berntsen et al., 2015; P. Hayes et al., 2009; Litz et al., 1996; Morey et al., 2009; Paunovic et al., 2002). Such problems may represent broader difficulty in emotional conflict detection, or the ability to accurately detect when emotional stimuli in the environment are mismatched (i.e., fear cues amidst safety cues). To date, the neural underpinnings of emotion conflict detection and its relationship to the etiology of PTSD are unclear.

Emotional conflict is studied using a task wherein participants attend to an emotional face (e.g., happy face) while an emotional word (e.g., “fear”) is superimposed on top of the face (Ekman, 1993; Etkin et al., 2006). Participants must identify the facial expression, filtering out the emotional distractor word. This task specifically measures how these emotional distractor words compete with an assessment of emotionally laden stimuli (i.e., facial expressions). To date, a few papers have examined the neural underpinnings of emotional conflict using this task during functional magnetic resonance imaging (fMRI; Etkin & Schatzberg, 2011; Etkin et al., 2006, 2010; Fonzo et al., 2016, 2017, 2019). Healthy individuals show greater engagement of the dorsomedial prefrontal cortex (dmPFC), dorsolateral prefrontal cortex (dlPFC), and the rostral anterior cingulate cortex (rACC; Etkin et al., 2006) when exposed to emotional conflict (i.e., incongruent trials where the face and word are mismatched) compared to no emotional conflict (i.e., congruent trials where the face and word are matched). Further, trauma-exposed individuals also preferentially recruit prefrontal regions (e.g., dlPFC) in addition to other regions outside the frontal cortex, including the insula, cerebellum, fusiform gyrus, temporoparietal junction, cingulate cortex, and precuneus (Fonzo et al., 2016). Thus, individuals exposed to trauma may rely on an extended network of brain regions for emotion conflict detection.

The implications of such findings as it relates to the development of PTSD are unclear as no significant differences between those with PTSD versus trauma-exposed healthy controls during this task have been found (Fonzo et al., 2016). Symptoms of PTSD are multidimensional and characterized in distinct domains organized by symptom clusters: reexperiencing, avoidance, negative mood, and hyperarousal (American Psychiatric Association, 2013). Differences in symptom presentation may obscure an underlying relationship whereby specific symptoms of the disorder may be uniquely tied to this disturbance, which has not been previously tested (Fonzo et al., 2016).

In the present study, we tested whether neural activation during emotional conflict (Etkin et al., 2006) predicted the development of PTSD symptom clusters. Traumatic injury survivors underwent fMRI neuroimaging shortly after injury (<1 month) for the assessment of emotional conflict neural response. We examined whether neural response predicted PTSD symptom cluster severity 6 months later as indexed by the Clinician-Administered PTSD Scale for DSM-5 (CAPS-5). We hypothesized that less engagement of frontal regions during emotional conflict detection (vs. no conflict detection), such as the dmPFC, dlPFC, and anterior cingulate cortex, would predict greater prospective severity of PTSD symptom clusters, specifically avoidance and hyperarousal given that these symptoms reflect disruption in matching emotional responses to context (Meyer et al., 2019; Murty et al., 2022).

# Method

## Participants

Traumatically injured adults ($N = 215$) were recruited from an urban Level-1 trauma center as part of a longitudinal study investigating neurobiological predictors of PTSD (iSTAR study; Tomas et al., 2022; Webb, Weis, Huggins, Fitzgerald, et al., 2021; Webb, Weis, Huggins, Parisi, et al., 2021). Eligibility was determined using self-report and medical records to assess whether individuals: (a) were 18–60 years old, (b) were English speaking, (c) met Diagnostic and Statistical Manual, fifth edition (DSM-5) Criterion A for a PTSD diagnosis (American Psychiatric Association, 2013), and (d) were at an increased risk for developing PTSD as qualified by a minimum score of three (out of five) on the Predicting PTSD Questionnaire (Rothbaum et al., 2014). Individuals were considered ineligible if they obtained a moderate to severe head injury (as indicated by a score <13 on the Glasgow Coma Scale (Sternbach, 2000), lower values indicate a severe head injury and ratings of 15 indicate normal), severe spinal cord injury, intentional self-inflicted injury, a history of psychotic/manic symptoms or substance abuse, severe vision or hearing impairments or were currently taking antipsychotic medications, in police-custody posttraumatic injury, left-handed, or MRI incompatible (e.g., presence of ferromagnetic material in the body). Study procedures were approved by the local Institutional Review Board and complied with the Helsinki Declaration. Written informed consent was obtained from all participants, and monetary compensation ($100) was provided for their time and effort.

## Procedure

Upon enrollment, participants completed an initial study visit (referred to as “T1”), within 1 month of a traumatic injury. During this visit, individuals completed an fMRI scan and self-report assessments. Participants returned for a follow-up study visit 6 months later (referred to as “T2”) to complete a structured interview assessing PTSD severity.

## T1 Assessments

At the T1 visit, participants provided comprehensive demographic information including gender, race, ethnicity, age, education, income, and mechanism of injury. Injury severity was obtained from medical records using the injury severity score (ISS), a standardized metric indicating traumatic injury severity (Baker et al., 1974). Participants also completed self-report measures which were used as covariates in the model. These included the PTSD Checklist for DSM-5 (PCL-5; Weathers, Litz, et al., 2013), the Depression Anxiety and Stress Scales (DASS-21; Lovibond & Lovibond, 2011), and the standard self-report version of the Life Events Checklist for DSM-5 (LEC-5; Weathers, Blake, et al., 2013). For the LEC, the standard total score was used which consists of a possible range of 0–51; higher scores indicate more trauma exposure with closer proximity (Weis et al., 2022). Participants also completed the Brief Perceived Ethnic Discrimination Questionnaire-Community Version (PEDQ-CV; Brondolo et al., 2005). Our prior work in urban Black/African American trauma survivors demonstrated the unique contribution of discrimination on brain functioning and PTSD prognosis following injury (Bird et al., 2021; Webb et al., 2022); given that our sample was majority Black, PEDQ-CV scores were added as a covariate in analyses examining prediction of PTSD severity.

## T2 Assessment of PTSD

Participants completed the Clinician-Administered PTSD Scale for DSM-5 (CAPS-5), a "gold-standard" structured interview PTSD assessment (Weathers et al., 2018) at the T2 visit, which evaluates PTSD severity by symptom cluster. Interviews were administered by a research staff member who completed rigorous and supervised training on the CAPS-5. Based on the intensity and frequency of the symptom, each item is given a severity rating of 0–4 (0 = *absent*, 4 = *extreme/incapacitating*). All 20 PTSD symptom items are summed to obtain a total symptom severity score, with a possible range of 0–80. The CAPS-5 has high internal consistency ($\alpha = .88$) and good test–retest reliability (intraclass correlation coefficient [ICC] = .78; Weathers et al., 2018). In the present study, an internal reliability check was conducted for CAPS-5 scores across two separate raters for 20% of the assessments. We found excellent agreement among raters ($\kappa = .83$, $p < .001$) and excellent reliability between total symptom severity scores (ICC = .96, 95% CI [0.93, 0.98]). For this analysis, CAPS-5 scores were calculated based on measure-specific scoring guidelines for each symptom cluster: reexperiencing, avoidance, negative mood, and hyperarousal. Total severity scores were also calculated (see the online supplemental materials).

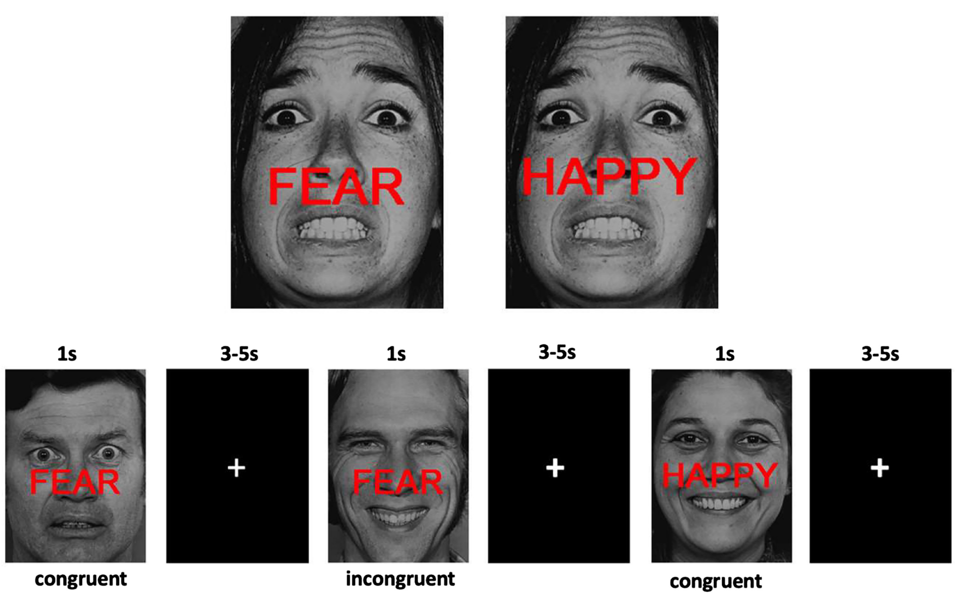
## T1 fMRI Acquisition

Functional neuroimaging data were acquired on a 3.0 Tesla short bore GE Discovery MR750 MRI system at the Medical College of Wisconsin. Functional T2*weighted echo-planar images (EPI) were collected in a sagittal orientation with the following parameters: repetition time (TR)/echo time (TE) = 2,000/25 ms; field of view (FOV) = 22.4 mm; matrix = 64 × 64; flip angle = 77°; slice thickness = 3.5 mm; voxel size = 3.5 × 3.5 × 3.5 mm; number of slices = 41; volumes = 192. A high-resolution T1-weighted anatomical image was also acquired for coregistration with the following parameters: TR/TE = 8.2/3.2 ms; FOV = 240 mm; matrix = 256 × 224; flip angle = 12°; voxel size = 0.9375 × 1.071 × 1 mm, number of slices = 150; length of run = 6 min 52 s; total number of images acquired = 206.

## T1 fMRI Task of Emotional Conflict

During the T1 fMRI scan, participants completed a well-validated emotional conflict task (Figure 1). Emotional distractor words, either "FEAR" or "HAPPY," were superimposed in red text over faces portraying congruent (e.g., "HAPPY" displayed on a happy face) or incongruent (e.g., "FEAR" displayed on a happy face) stimuli (Etkin et al., 2006). Participants were asked to identify the emotion expressed on the face via a button press as quickly and accurately as possible. Stimuli were electronically presented using E-Prime 2.0 software (Psychology Software Tools, 2013). Participants

**Figure 1**
*Emotional Conflict Task*




*Note*. Adapted from "Resolving Emotional Conflict: A Role for the Rostral Anterior Cingulate Cortex in Modulating Activity in the Amygdala," by A. Etkin, T. Egner, D. M. Peraza, E. R. Kandel, and J. Hirsch, 2006, *Neuron*, *51*(6), pp. 871–882 (https://doi.org/10.1016/j.neuron.2006.07.029). Copyright 2006 by Elsevier. Adapted with permission. See the online article for the color version of this figure.

completed 148 trials, across two runs. Each trial was presented for 1,000 ms, with a jittered interstimulus interval (ISI) of 3,000–5,000 ms (mean ISI = 4,000 ms), during which a white crosshair was presented. The task was 6 min and 52 s and was part of a larger fMRI protocol totaling 1.5 hr. Faces depicted White individuals of varied age; gender of the face was randomized and equal across conditions (incongruent and congruent) and emotion type (fear and happy). To avoid negative priming and repetition priming effects, no consecutive presentations of the same face occurred.

Neural processes of emotional conflict detection were analyzed by comparing incongruent > congruent trials, which elicit cortical regions necessary for emotional appraisal and attentional (Fonzo et al., 2016). By contrast, prior work consistently shows that brain regions are not preferentially recruited in the congruent > incongruent contrast (Etkin et al., 2006; Fonzo et al., 2016). As an exploratory analysis, we investigated trial patterns as previous research shows that the type of trial (incongruent and congruent) preceding an incongruent trial differently affects cortical recruitment (Etkin et al., 2006; Fonzo et al., 2016; Powers et al., 2015). Specifically, incongruent trials preceded by a congruent trial reflect low conflict resolution instances, whereby participants are not primed to resolve emotional conflict, and participants maintain a high emotional conflict state as evidenced by greater dorsal and medial activation (e.g., dmPFC; Etkin et al., 2006). Conversely, incongruent trials preceded by an incongruent trial reflect high conflict resolution and elicit greater rostral and ventral activation (e.g., rACC; Etkin et al., 2006). Incongruent trials were, therefore, also modeled based on preceding trial, resulting in incongruent–incongruent trials and congruent–incongruent trials, the results of which are presented in the online supplemental materials.

## Data Analysis

### *Behavioral Data Analysis*

Behavioral data were analyzed using Statistical Package for the Social Sciences, Version 28.0 (IBM Corp., 2021). See the online supplemental materials for details on behavioral data analysis.

### *fMRI Preprocessing*

Standard preprocessing steps were completed in Statistical Parametric Mapping (SPM12) software package (Wellcome Trust Centre for Neuroimaging, London). To allow for signal stabilization, the first three volumes were trimmed from images. To account for slice time acquisition differences, images were temporally corrected and then spatially realigned to the mean image. To control for head motion during the scan, motion realignment parameters (*x*-, *y*-, *z*-, pitch-, yaw-, roll-) were entered as regressors of no-interest. Subjects with absolute motion > 3 mm or >3° rotation in any one direction were excluded from analyses. Images were subsequently normalized to a Montreal Neurological Institute (MNI) template using the echo-planar imaging template, resampled to 2 × 2 × 2 voxels and smoothed using a 4 mm isotropic Gaussian kernel. A general linear model was applied to the time series, convolved with the canonical hemodynamic response function and with a 128-s high-pass filter. Temporal autocorrelation was accounted for using the FAST option in SPM12 (Bollmann et al., 2018; Corbin et al., 2018; Olszowy et al., 2019; Todd et al., 2016). Hemodynamic response during rest, incongruent, and congruent trials was separately modeled, collapsed across emotion type (fear and happy), and estimated for each voxel for each participant.

### *Prediction of PTSD at T2*

Effects were evaluated using the contrast of incongruent > congruent at the second level. Separate regression models were used, regressing CAPS-5 symptom clusters (reexperiencing, avoidance, negative mood, hyperarousal) onto neural response. Age and gender (dummy coded; 0 = *male*) were covariates of no-interest given their documented implication in differential PTSD outcomes (McGinty et al., 2021), along with ISS to quantify injury severity. T1 PCL-5 symptom clusters, LEC-5, PEDQ-CV, and DASS-depression subscale scores were covariates of no-interest to account for PTSD, depression severity, trauma load, and racial discrimination at the time of scanning in PTSD prediction. Depression severity was chosen due to high concordance between PTSD and major depressive disorder (Kessler et al., 2005).

Results were evaluated within a mask derived from task effects across the whole group (derived using a $p < .05$ uncorrected threshold with a cluster size of $k \geq 10$) specific to the incongruent > congruent contrast. Task effects are reported in the online supplemental materials, including the association between performance (reaction time and accuracy) and neural response.

For main analyses on PTSD prediction, given the number of tests (four symptom clusters), we used a Bonferroni correction and adjusted accordingly ($\alpha = .0125$) such that clusters were considered significant if they survived cluster-extent based thresholding (family-wise error [FWE] $p < .0125$; Roiser et al., 2016; van Rooij et al., 2018; Woo et al., 2014). For significant clusters, beta-weights in arbitrary units were extracted using the SPM MarsBar toolbox (Brett et al., 2002) for visual inspection and graphing purposes.

# Results

## Participants

Of the participants enrolled in the study ($N = 215$), a total of 82 participants were available for analysis based on completion of the emotional conflict task during fMRI scanning. Of the 82 participants, 23 participants were excluded from analysis due to excessive movement during scanning (e.g., ≥ 3 mm in any one direction). Ten participants did not complete follow-up CAPS-5 interviews; thus, participants retained for T1 task effects included $N = 59$ while the sample size for predicting CAPS-5 symptom clusters was $N = 49$ (based on the available T2 data). See Table 1 for sample characteristics, reflecting participant information at T1 and T2. Average time between injury and T1 and T2 laboratory visits was 16.76 and 184.67 days, respectively.

Overall, self-report and clinician-assessed total symptom severity reflected mild PTSD symptoms both acutely (mean T1 PCL-5 = 26.08) and 6-month posttrauma (mean T2 PCL-5 = 27.27 and CAPS-5-total = 11.84). CAPS-5 symptom cluster scores (reexperiencing, negative mood, and hyperarousal) were significantly correlated with corresponding T1 PCL-5 subscales ($ps < .05$), except for CAPS-5 avoidance scores, which were not significantly related to T1 PCL-5 avoidance scores ($p = .14$). DASS-depression at T1 was correlated with T2 CAPS-5 Negative Mood scores ($r = .37$, $p = .009$), but not CAPS-reexperiencing, avoidance, or hyperarousal

**Table 1**
*Demographic Characteristics of Participants at Baseline (T1) and 6-Month Follow-Up (T2)*

| Demographic variable | T1 ($n = 59$) *M* (*SD*) | T2 ($n = 49$) *M* (*SD*) |
|---|---|---|
| Age | 31.94 (9.96) | 32.85 (10.05) |
| | T1 ($n = 59$) *n* (%) | T2 ($n = 49$) *n* (%) |
| Gender (female) | 30 (50.85%) | 26 (53.06%) |
| Race | | |
| White | 21 (35.59%) | 17 (34.69%) |
| Black/African American | 26 (44.07%) | 23 (46.94%) |
| Asian | 3 (5.08%) | 2 (4.08%) |
| More than one race | 6 (10.17%) | 4 (8.16%) |
| Other or unknown | 3 (5.08%) | 3 (6.12%) |
| Ethnicity (Hispanic) | 3 (5.08%) | 3 (6.12%) |
| Income (dollars) | | |
| 0–10,000 | 15 (25.42%) | 12 (24.49%) |
| 10–30,000 | 17 (28.81%) | 15 (30.61%) |
| 30–50,000 | 7 (11.86%) | 6 (12.24%) |
| 50–70,000 | 9 (15.25%) | 7 (14.29%) |
| 70–100,000 | 6 (10.17%) | 6 (12.24%) |
| Greater than 100,000 | 5 (8.47%) | 3 (6.12%) |
| Education | | |
| 11th grade | 1 (1.69%) | 1 (2.04%) |
| High school graduate/equivalent | 27 (45.76%) | 23 (46.94%) |
| Some college no degree | 14 (23.73%) | 10 (20.41%) |
| Associate degree | 8 (13.55%) | 8 (16.33%) |
| Bachelor's degree | 8 (13.56%) | 6 (12.24%) |
| Master's degree | 1 (1.69%) | 1 (2.04%) |
| Mechanism of injury | | |
| Motor vehicle crash | 36 (61.02%) | 31 (63.3%) |
| Pedestrian struck | 2 (3.39%) | 2 (4.08%) |
| Crush injury | 2 (3.39%) | 1 (2.04%) |
| Domestic violence | 2 (3.39%) | 2 (4.08%) |
| Assault/altercation | 10 (16.95%) | 8 (16.32%) |
| Other | 7 (11.86%) | 5 (10.20%) |
| | T1 ($n = 59$) *M* (*SD*) | T2 ($n = 49$) *M* (*SD*) |
| CAPS-5 | | |
| Total severity | | 11.84 (9.10) |
| Re-experiencing | | 3.53 (3.16) |
| Avoidance | | 2.08 (1.66) |
| Negative mood | | 2.69 (3.80) |
| Hyperarousal | | 3.53 (2.81) |
| PCL-5 | | |
| Total severity | 26.08 (16.95) | 27.27 (17.34) |
| Reexperiencing | 7.64 (5.30) | 6.14 (5.15) |
| Avoidance | 3.22 (2.38) | 2.65 (2.10) |
| Negative mood | 7.44 (6.55) | 6.67 (7.27) |
| Hyperarousal | 7.78 (5.01) | 7.29 (6.14) |
| LEC-5 | 16.97 (9.94) | 16.88 (9.80) |
| DASS-depression | 8.85 (8.68) | 9.55 (8.84) |
| PEDQ-CV | 1.77 (0.82) | 1.78 (0.81) |
| ISS | 0.57 (1.23) | .49 (1.12) |
| Time since injury (days) | 16.76 (4.9) | 184.67 (12.99) |

*Note.* Sample at T2 reflects those individuals who returned for completion of CAPS-5 for assessment of PTSD; ISS scores were missing on $n = 1$ individuals at T1. CAPS-5 = Clinician-Administered PTSD Scale for DSM-5; PCL-5 = PTSD Checklist for DSM-5; LEC-5 = Life Events Checklist for DSM-5; DASS-Depression = Depression subscale of the Depression, Anxiety, and Stress Scales (21-item); PEDQ-CV = Brief Perceived Ethnic Discrimination Questionnaire—Community Version; ISS = injury severity score; T1 = Time 1; T2 = Time 2.

scores (*ps* > .05). See Table S1 in the online supplemental materials for correlations among T1 and T2 self-assessment and clinical scores.

Individuals dropped for movement did not significantly differ with respect to age, gender, race, ethnicity, PCL-5, DASS-depression, PEDQ-CV, LEC-5, CAPS-5 reexperiencing, avoidance, negative mood, or hyperarousal scores (*ps* > .05).

## Behavior

See the online supplemental materials for behavioral results.

## fMRI Prediction of PTSD at T2

### *Incongruent > Congruent (Conflict Detection Compared to No Conflict Detection)*

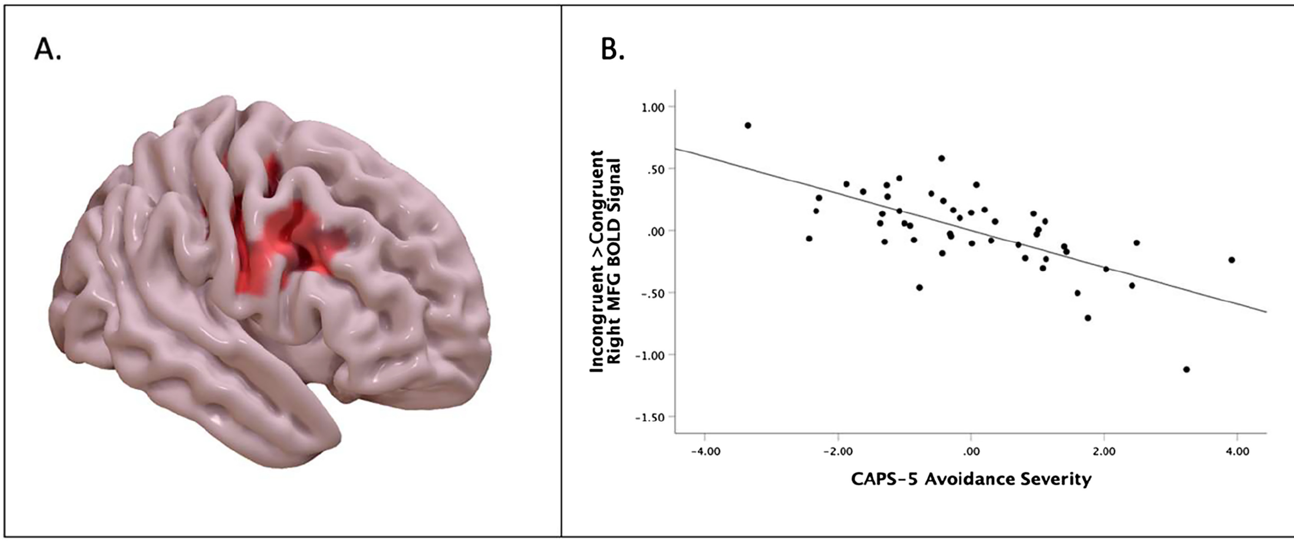
During the incongruent compared to the congruent trials, greater activation in the right middle frontal gyrus (MFG) significantly predicted lower CAPS-5 Avoidance scores (peak MNI: 38, 16, 32; $T = 5.09$, $Z = 4.44$, $k = 138$) ($p = .007$ cluster-level FWE-adjusted). Figure 2 depicts the relationship between CAPS-5 Avoidance scores and right MFG. There was no significant relationship between CAPS-5 reexperiencing, negative mood, or hyperarousal scores and neural activation ($p > .0125$ cluster-level FWE-adjusted).

# Discussion

In this study, we assessed neural response collected in the acute aftermath of a traumatic injury (<1 month) during an emotional conflict task using fearful and happy faces. Critically, greater activation of the right MFG during emotional conflict detection (compared to no emotional conflict detection) predicted lower PTSD avoidance symptom severity 6 months later. These results demonstrate that neural activity during an emotional conflict task is informative for predicting PTSD symptom development; moreover, effects were significant even when adjusting for self-reported baseline PTSD and depressive symptoms, traumatic life events, perceived racial discrimination, age, sex, and injury severity, demonstrating incremental predictive utility beyond known risk factors. In addition, we found evidence of specificity, such that neural activation predicted the development of avoidance symptoms only.

The PTSD avoidance symptom cluster comprises effortfully avoiding thoughts and reminders of a traumatic event (U.S. Department of Veterans Affairs, 2023), theorized to arise from sensitivity to external and internal stimuli that remind individuals of their traumatic event (Thompson & Waltz, 2010). Over time, this may generalize to unrelated stimuli, reflecting an impaired ability to discriminate between traumatic event and nontraumatic event cues (Blackledge, 2004). The MFG is heavily involved in executive control processes, namely attention (Dixon et al., 2018; He et al., 2007) and working memory (Camilleri et al., 2018; Emch et al., 2019). The right MFG has been implicated in PTSD. One longitudinal examination of coal-mining accident survivors showed that right MFG activation while viewing traumatic vs. neutral images was correlated with PTSD symptom severity, such that greater reduction in activation from baseline (2-month posttrauma) to follow-up (2-year posttrauma) in this region was associated with greater PTSD symptom reduction (Ke et al., 2016). Our results show that greater activation in this region during emotional conflict detection predicts lower PTSD avoidance symptoms 6 months later. Thus, greater right MFG activation in the acute aftermath of trauma may be protective against the development of PTSD symptoms, specifically avoidance, via an enhanced ability to

**Figure 2**
*Neural Activation During Emotional Conflict Detection Predicts PTSD Avoidance Symptoms*




*Note.* Spatial location of the right MFG cluster reflected as arbitrary units of BOLD signal (Panel A), and scatterplot illustrating lower Avoidance symptoms at 6 months were related to greater T1 activation in the right MFG ($p = .007$; accounting for all covariates in the model) (Panel B). PTSD = posttraumatic stress disorder; MFG = middle frontal gyrus; BOLD = blood oxygenation level-dependent; T1 = Time 1. See the online article for the color version of this figure.

attend to new, conflicting information (i.e., mismatched word and face valence) and integrate it into previously learned information (i.e., instructions to identify the valence of the face).

As hypothesized and consistent with previous research, task performance during conflict detection was related to greater engagement of the right dmPFC, irrespective of PTSD severity. This replicates past work demonstrating cortical recruitment during emotion conflict detection (Etkin et al., 2006). Cognitive control can be impacted by emotionally salient information, or emotion interference (Song et al., 2017), and this may contribute to emotion dysregulation in PTSD (J. P. Hayes et al., 2012). However, we did not find evidence that prefrontal cortical activation during emotional conflict detection predicted PTSD severity.

It is important to note several limitations of this study. First, all were trauma-exposed and we were unable parse out the effects of trauma versus developing PTSD. Participants, on average, exhibited mild PTSD symptoms 6 months postinjury, although this is expected as ~80% of trauma survivors are resilient to the development of PTSD (deRoon-Cassini et al., 2010). The makeup of our sample was limited in respect to traumatic injury and we are unable to generalize these findings to all trauma types. Given the greater impact of traumatic injuries caused by interpersonal violence compared to noninterpersonal violence (e.g., motor vehicle crashes; Cody & Beck, 2014), future investigations should explore differences in cause of traumatic injury. Further, the stimuli presented in the emotional conflict task were exclusively of White individuals, while our sample was majority Black. Prior work demonstrates that ingroup versus outgroup membership status influences perception of emotion (Wang et al., 2014). Relatedly, while we included experiences of racial discrimination as a covariate in our analyses, we used a single measure of this construct, which may be limited in controlling for such effects. Finally, the sample was comparatively small, and more work is needed in larger samples of traumatic-injury survivors (Marek et al., 2022).

In conclusion, findings provide evidence in a unique sample assessed in the acute aftermath of a traumatic injury. Specifically, neural processes of emotion conflict detection measured in the early aftermath of a traumatic injury predict the development of PTSD avoidance symptoms. Results underscore the heterogeneous nature of PTSD, such that differential neural profiles during emotional conflict detection predicted symptom clusters, specifically avoidance. Thus, such effects may serve as an impetus for future research to use nuanced approaches to predict specific PTSD symptom clusters.

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