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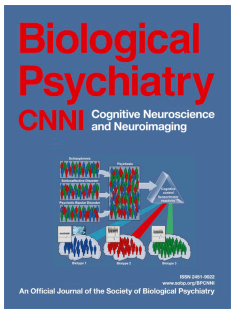

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Running head: MORAL INJURY AND FUNCTIONAL CONNECTIVITY

Civilian Moral Injury and Amygdala Functional Connectivity During Attention to Threat

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Abstract

Background: Moral injury references emotional and spiritual/existential suffering that may emerge following psychological trauma. Despite being linked to adverse mental health outcomes, little is known about the neurophysiological mechanisms of this phenomenon. In this study, we examined neural correlates of moral injury exposure and distress using the Moral Injury Events and Symptom Scale for Civilians (MIESS-C). We also examined potential moderation of these effects by race (Black vs White individuals), given the likely intersection of race-related stress with moral injury.

Methods: Forty-eight adults aged 18-65 (M_{age}=30.56, SD=11.93) completed the MIESS-C and an affective attentional control measure, the affective Stroop task (AS), during fMRI; the AS includes presentation of threat-relevant and neutral distractor stimuli. Voxel-wise functional connectivity of the bilateral amygdala was examined in response to threat-relevant vs neutral AS distractor trials.

Results: Functional connectivity between the right amygdala and left postcentral gyrus/primary somatosensory cortex was positively correlated with MIESS-C exposure score (voxel-wise $p<.001$, cluster false discovery rate-corrected $p<.05$) in response to threat vs neutral AS distractor trials. Follow-up analyses revealed significant effects of race; Black but not White participants demonstrated this significant pattern of amygdala-left SSC connectivity.

Conclusions: Increased exposure to potentially morally injurious events may lead to emotion-somatosensory pathway disruptions during attention to threat-relevant stimuli. These effects may be most potent for individuals who have experienced multilayered exposure to morally injurious events, including racial trauma. Moral injury appears to have a distinct neurobiological signature that involves abnormalities in connectivity of emotion-somatosensory paths, which may be amplified by race-related stress.

Moral injury (MI), often defined as suffering related to violations of one's moral beliefs or values in high stakes situations, may develop in the aftermath of psychological trauma. In the past decade, MI has increasingly been highlighted in studies with military-connected populations[1], particularly in reference to acts such as killing civilians or failing to prevent the injury or suffering of a fellow service member. However, MI is not exclusive to service members or combat veterans; many types of civilian trauma may have a morally injurious component (e.g., feeling betrayed by a family member who perpetrated sexual abuse). Limited studies have examined MI in civilians, including refugees[2-4], teachers[5], journalists[6], and undergraduates[7]. In the past couple years, MI in healthcare workers during the COVID-19 pandemic has also been examined, illustrating the broad impact of this source of suffering.[8]

In recent years, MI has been examined in the context of chronic civilian trauma. Two aspects of MI, frequency of exposure to events appraised as being morally injurious (moral injury exposure; MIE) and distress related to morally injurious events (moral injury distress; MID) have been assessed in Black American participants of the Grady Trauma Project[9, 10], a long-standing trauma study; participants in GTP report frequent trauma exposure (on average, exposure to four different types of trauma over the lifetime[11, 12]) and high rates of current and lifetime post-traumatic stress disorder (PTSD). In this and other similar populations, MI has been associated with adverse mental health outcomes, including PTSD, major depressive disorder, substance use disorder, and suicide behaviors, as well as negative physical health outcomes[1]. We recently observed that MIE and MID were also associated with autonomic dysregulation in the form of lower high-frequency heart rate variability, and also observed indirect effects of MID on the relationship between sexual trauma exposure and high-frequency heart rate variability[9].

Although aspects of MI (feelings of shame or guilt) overlap with PTSD, some features of MI are unique (e.g., feelings of betrayal, difficulties with self-forgiveness, loss of faith in institutions or a higher power). Further, in a civilian context, moral injury can emerge in the aftermath of events that are not within the DSM-5 definition of trauma for a PTSD diagnosis. As such, MI may also have distinct neurophysiological correlates as compared to PTSD; however, less than a handful of studies have examined biomarkers of MI, including neural correlates.

In one study, resting-state connectivity of the left inferior parietal lobe and precuneus was negatively associated with MI but positively associated with PTSD symptoms in a small study of veterans (n=26)[13]. Another fMRI study comparing individuals with military/public safety or civilian-related trauma observed greater functional network connectivity in the midbrain periaqueductal grey and cerebellum in civilians with PTSD as compared to healthy controls in response to autobiographical scripts that represented a morally injurious event[14]. A third study conducted with the same population observed that, in response to morally injurious vs neutral event recall, participants with PTSD showed increased functional activation in the dorsal anterior cingulate cortex, the dorsolateral prefrontal cortex, insula, and postcentral gyrus[15]. These studies highlight the interaction of MI and PTSD in regions related to threat detection as well as somatosensory awareness. Notably, the authors mention that participants described visceral experiences during the MI recall, such as pain and nausea[15] highlighting the salience of

somatosensory aspects of moral injury. However, no studies to date have examined how civilian MI, including MIE and MID, associate with functional brain connectivity in response to threat-relevant cues.

The findings of these studies suggest that networks involved in threat detection may play a role in the neural circuitry of MI. Further, moral injury appraisals involve detection of extreme norm violations, a function that has been most consistently attributed to the amygdala[16, 17]. Given the well-established role of the amygdala in threat detection[18], emotional processing more generally[19, 20], and detection of social norm violations[16, 17], this region is an attractive target for investigating connectivity in neural networks associated with MIE and MID. As such, the primary goal of this study was to investigate the relationships of MIE and MID with amygdala functional connectivity during attention to threat-relevant cues in a sample of trauma-exposed civilians. We conducted seed-to-voxel connectivity analyses with the amygdala as the seed region to examine potential disruptions in functional connectivity of emotion processing networks in association with MI[18, 21].

Secondarily, we conducted an exploratory follow up analysis to examine potential race-related differences in findings. Black Americans experience greater levels of psychological stress compared to White Americans[22, 23] often in the form of race-related stressors[24]. Increased exposure to such stressors can contribute to anticipatory vigilance[25] whereby individuals of minoritized racial backgrounds pay increased attention to potential threats in their environment. Previous studies have demonstrated that trauma-exposed Black Americans, compared to White Americans, experience increased vigilance characterized by alterations in threat detection circuits[26] as well as altered amygdala activity in response to threat-related cues[27] and changes in functional connectivity after exposure to traumatic events.[28] Although research has not yet explored the associations between race and MI, previous work has suggested that racial-ethnic minority status, among other factors, may contribute to increased risk of experiencing potentially morally injurious events[29], and that Black Americans tend to experience more negative psychological outcomes following trauma exposure than White Americans.[30] Given that approximately half of our participants were Black, and the likely intersection of race-related stress with MI, we conducted moderation analyses with regions that emerged in primary analyses to assess whether observed effects were moderated by race (Black vs White individuals).

Methods

Participants: Forty-eight adults (93.8% female, $n = 45$, 6.3% male, $n = 3$) aged 18-65 (Mean: 30.56 years, SD: 11.93 years) were recruited from either of two mindfulness intervention studies for trauma-exposed individuals in the context of the Grady Trauma Project (GTP), Physiological Augmentation of Mindfulness Meditation (PAMM; NCT02754557) and Mechanistic Interventions and Neuroscience of Dissociation (MIND; NCT04670640). Inclusion criteria for these studies were as follows: exposure to psychological trauma, as defined by the DSM-5, > 18 years but ≤ 65 years of age. Eligibility for the PAMM and MIND studies is detailed in the Supplement. After informed consent was given, enrolled participants completed measures of trauma exposure, PTSD, and moral injury. At a separate visit, participants completed an affective

attentional control task during fMRI, the affective Stroop (AS),[31-33] detailed below. Pre-intervention scans were used in analyses.

Trauma Exposure: The Childhood Trauma Questionnaire (CTQ) was used to assess participants' exposure to childhood maltreatment[34]. The Traumatic Events Inventory (TEI) was used to assess trauma exposure in the lifetime, excluding maltreatment; the TEI was developed in the context of the GTP, and assesses a range of DSM-IV/5 PTSD Criterion A stressors, as detailed previously[11], yielding a summed total of types of trauma.

The Moral Injury Events Exposure Scale – Civilian: The MIESS-C[10] is a 10-item scale adapted from a military moral injury measure, the MIES[35], to assess exposure to potentially morally injurious events and distress related to these events in civilians. This measure was administered after our trauma measure, the TEI; however, MIESS-C responses were not necessarily tied to a particular traumatic event. Participants responded to questions using a six-point scale, with responses ranging from strongly disagree to strongly agree; higher scores suggest higher moral injury exposure and/or distress. The MIESS-C has two summed subscale scores to distinguish *exposure* to potentially morally injurious events (MIE; possible score range=5-30) from *distress* related to morally injurious events (MID; possible score range=5-30). Internal consistencies of the two subscales were in the acceptable range[36] (Cronbach's alpha MIE = .67; MID = .76). MIESS-C items are detailed in the Supplement.

PTSD: Symptoms of current PTSD were assessed with either of two measures with comparable psychometric properties[37]; the Modified Posttraumatic Symptom Scale (MPSS),[38] which assesses PTSD symptoms in accordance with the DSM-IV (used in PAMM; n=20); the PTSD Symptom Checklist DSM-5 (PCL-5)[39] which assesses PTSD symptoms in accordance with the DSM-5 (used in MIND; n=28). Given the similarity of these two measures[37], total scores for the MPSS and PCL-5 were natural-log transformed as a means to standardize and harmonize these measures before being entered into statistical analyses.

Affective Stroop Task: The affective Stroop (AS) task was presented during fMRI as an assay of attention in the context of emotionally salient cues. The task (detailed further in the Supplement and illustrated in Supplemental Figure 1) involves presentation of a number array (400 ms duration) that is either congruent or incongruent with the actual number presented (i.e., the number 4 presented in an array of 4; the number 3 presented in an array of 5); participants are asked to indicate the numerosity of the stimulus image with a button press. Prior to and after the number stimulus, a distractor image stimulus is presented displaying a threat-relevant, neutral, or positive scene. The task comprises 16 number congruent and 16 number incongruent trials for the three types of distractor images. An additional 16 passive view trials for each of the three distractor image types were also presented, as well as 40 fixation trials (2500 ms duration), for a total of 184 trials; trial types were randomized. First-level models were created for each participant for each emotion (threat-relevant, positive, neutral) and cognitive condition (number incongruent, number congruent, passive viewing); we examined amygdala connectivity during presentation of threat-relevant vs neutral distractor stimuli in primary analyses, similar to our prior trauma studies[26, 40].

MRI data acquisition and processing: T1- and T2*-weighted images were acquired on one of three research-dedicated Siemens 3T MRI Systems, acquisition parameters are detailed in the Supplement. Sequence parameters were altered slightly to accommodate different scanner models (Supplemental Table 1).

Connectivity Analyses: All images were preprocessed using the default preprocessing pipeline within CONN Toolbox[41] (v20.b; https://www.nitrc.org/projects/conn/) (v20.b; https://www.nitrc.org/projects/conn/) which included realignment and unwarping, slice-timing correction, outlier detection, direct segmentation and normalization and smoothing using a gaussian kernel of 6mm. A total of 24 motion and physiological noise regressors were created based on the anatomical component-based noise correction method or a CompCor[42] to be later used as confound regressors in the subject-level general linear model (GLM). A high-pass cutoff of 0.008Hz was used to remove low-frequency drifts in the time series data. No participants were excluded for image quality issues or excessive movement.

We then conducted seed-to-voxel generalized psychophysiological interaction (gPPI[43]) analyses within the CONN toolbox to investigate associations of MI metrics with amygdala functional connectivity during threat-relevant vs neutral AS distractor trials. This automated method allows task-dependent connectivity analyses for tasks containing more than 2 conditions. Using the gPPI method resulted in separate models for each task condition. Given our interest in examining functional connectivity during threat-relevant AS conditions, our primary contrast of interest was threat-relevant AS trials (including number congruent, number incongruent, and view-only trials) vs. neutral AS trials (including number congruent, number incongruent, and view-only trials). Connectivity analyses were conducted using bivariate regression; we included MIE and MID as regressors in separate gPPI models to explore variance in connectivity associated with each index. Group-level Fisher-transformed z-statistics were generated in CONN, which represented magnitude and direction (increase or decrease) of connectivity associated with MIE or MID for our contrast of interest, trauma-relevant vs. neutral trials. The bilateral amygdala, defined using the Wake Forest PickAtlas (https://www.nitrc.org/projects/wfu_pickatlas/), was the seed region for seed-to-voxel analyses. Group-level gPPI contrast maps were corrected for multiple comparisons using a voxel-wise cluster forming threshold of $p<0.001$ and cluster significance threshold (False Discovery Rate (FDR)-corrected) of $p<0.05$. Where significant findings were observed, follow-up voxel-wise sensitivity regression analyses were conducted controlling for scanner type and current PTSD symptoms to account for these effects. For analyses of race-related differences in observed effects, connectivity values were extracted from significant clusters to assess whether race (Black participants compared to White participants) moderated any observed patterns of associations between MI and amygdala connectivity using the SPSS PROCESS macro.

Results

Distribution of MIESS-C subscale scores did not display evidence of non-Gaussian distribution: MIE (Shapiro-Wilk statistic=.97, p=.19); MID (Shapiro-Wilk statistic=.96, p=.09). Neither MIE nor MID were significantly associated with biological sex, race, educational level, current employment, or monthly household income (all *p*s>.05). However, MIE and MID were

significantly associated with childhood maltreatment, adult trauma exposure, and current PTSD symptoms, as anticipated (Table 1; all *p*s<.05).

Main effects of amygdala connectivity for each emotion condition are detailed in Supplemental Table 2. In the group as a whole, seed-to-voxel connectivity analyses to threat-relevant vs neutral AS trials revealed significantly greater bilateral amygdala connectivity with three large clusters in the temporal occipital fusiform cortex ($MNI_{X,Y,Z}$=-50, -50, -22), inferior frontal gyrus ($MNI_{X,Y,Z}$= 50, 28, 10), and supramarginal gyrus ($MNI_{X,Y,Z}$= 58, -44, 22) (Supplemental Table 2).

Seed-to-voxel regression analysis to threat-relevant vs neutral AS trials with moral injury exposure (MIE) score as regressor revealed significantly greater bilateral amygdala connectivity to a single large cluster in the left post-central gyrus/primary somatosensory cortex (SSC) ($MNI_{X,Y,Z}$= -28, -32, 64), k=213 (Figure 1). This cluster remained significant after follow-up sensitivity analysis with scanner site and PTSD symptom severity included as covariates ($MNI_{X,Y,Z}$= -28, -32, 62, k=99). Upon further examination, the observed pattern of connectivity was only significant for the right amygdala (r=.48, p=.001) and was driven by greater negative right amygdala-SSC connectivity to neutral trials (r=-0.58, p<0.001) as compared to threat-relevant trials (r=0.18, p=0.233). Two relative outliers were identified in the connectivity data (two standard deviations below the group mean); as such we repeated the MIE analysis without these two data points; findings were relatively unchanged (detailed in Supplement). Seed-to-voxel regression analysis with only PTSD symptom severity as regressor revealed no significant results, as detailed in the Supplement

Seed-to-voxel regression analysis to threat-relevant vs neutral AS trials with moral injury distress (MID) score as regressor did not reveal any significant associations of amygdala connectivity with any brain region at our statistical threshold. Main effects of MIE on amygdala connectivity for each emotion condition are detailed in Supplemental Table 3. No significant correlations were observed between MIE, MID, and error or response time on either threat-relevant or neutral AS distractor trials (Table 2; all *p*s>.05).

Given the findings with MIE, we conducted an exploratory post-hoc ~~follow-up~~ analyses to assess for differences in associations between MIE and right amygdala-left primary somatosensory cortex connectivity between Black (n=21) and White (n=18) participants after accounting for variance associated with PTSD. We found a significant interaction of race with MIE on amygdala-left SSC connectivity ($F_{1,35}$=11.33, p=.002). Examination of the interaction plot revealed positive associations between MIE and SSC connectivity in Black (t_{21}=6.12, p<.001, LLCI=.0789, ULCI=.1572) but not White participants (t_{18}=.55, p=.555, LLCI=-.03, ULCI=.06; Figure 2) and that this moderation was driven by greater negative bilateral amygdala-SSC connectivity in response to neutral AS trials in Black (t_{21}=-5.35, p<.001, LLCI=.09, ULCI=.18) but not White (t_{18}=.74, p=.467, LLCI=-.03, ULCI=.07) participants. We explored potential differences/inequities in economic and other resources between Black and White participants. Black participants reported marginally more disability support (X^2=3.82, p=.051) and marginally less private insurance support (X^2=8.52, p=.074) as compared to White participants, detailed in Supplemental Table 4.

Discussion

In this study, we examined associations between civilian MI, specifically exposure to potentially morally injurious events (MIE) and related distress (MID), and amygdala connectivity during attention to threat-relevant vs neutral cues in a sample of trauma-exposed individuals. Participants who endorsed experiencing more exposure to potentially morally injurious events demonstrated disruptions in amygdala connectivity to the left postcentral gyrus/primary somatosensory cortex (SSC) during attention to threat-relevant vs neutral stimuli. These findings persisted even after accounting for variance related to PTSD symptoms, indicating that the associations may be more attributable to moral injury. Exploratory moderation analysis indicated that race interacted with these associations; Black, but not White, individuals demonstrated this positive connectivity between the amygdala and SSC.

Our findings are similar to a prior study of MI in civilians, which also demonstrated increased activation in the left SSC in response to recall of morally injurious events[15]; however, in the prior study, findings were specific to participants with PTSD. Here, we observe that MI exposure, but not distress, was associated with greater connectivity between the amygdala, a brain region that is critical to threat detection, and the SSC, even after accounting for variance due to current PTSD symptoms. The SSC is essential to sensory processes such as touch, proprioception, pain, and temperature, with primary input from the thalamus. However, the SSC has widespread afferent pathways,[44] and has indirect connections with the amygdala via the thalamus.[45] As such, the SSC is thought to play various roles in emotion regulation.[46] This includes emotion recognition,[45] generation of emotional responses[47] as well as interoception, which references the awareness and integration of afferent visceral information.[48] The detection of body signals (e.g., muscle tension) and connection of these signals with emotional states (e.g., feeling threatened) is critical to adaptive emotion regulation. As such, disruptions in this emotion processing-somatosensory pathway related to MIE can perturb interoceptive awareness, which, in turn, can interfere with emotion regulation. Similarly, this may indicate a salient mechanistic target for a range of MI interventions, from mindfulness practices to neuromodulation and drug-assisted psychotherapy. Mind-body interventions, such as breath-focused mindfulness, are centered around the use of body sensations to anchor attention and improve emotion regulation, and as such, may be ideal as a monotherapy or augmenting component to exposure-based trauma interventions.

Notably, increased amygdala-SSC connectivity has been linked to greater pain facilitation in the context of negative emotions.[49] Exposure to more potentially morally injurious events has been linked to chronic pain,[50, 51] including a large-scale study of veterans, which observed strong associations with perceived pain intensity. It is likely that MIE modulates somatosensory experiences, including pain, and could serve as a basis for chronic pain disorders.[51] Although not assessed in the present study, the experience of MI has been described as physically painful for some survivors[52] and exposure to more potentially morally injurious events could amplify the experience of pain in various contexts. Given the fact that activation in amygdala and SSC has been associated with empathy,[53] it is possible that this neural signature reflects an enhanced awareness and subsequent responsiveness to others' painful

experiences. However, in the absence of data, this is merely speculative, and further research that includes assessments of pain and empathy are needed to provide clarity on these relationships.

We observed that the associations of MIE and functional connectivity were moderated by race, with Black participants demonstrating this pattern of altered amygdala-SSC connectivity in association with MIE. Black individuals are likely to encounter potentially morally injurious events that are also race-related stressors (e.g., the murder of George Floyd as an example of betrayal by institutions); a recent study using the MIES for veterans demonstrated that, compared to non-White veterans, White veterans less frequently endorsed moral injury.[29] Greater exposure to race-related stressors such as racial discrimination has been linked to more intense experiences of physical pain[54] as well as increased incidence of chronic pain conditions.[55] In this study we did not assess experience of pain, so we were unable to test any hypotheses related to chronic pain or affective experiences of pain. However, earlier studies have observed race-related differences in structure and function in overlapping brain regions in Black Americans that were linked to structural inequities[28, 56]. Notably, in this study we observed some marginal race-related differences in economic and health resources (i.e., health insurance); although these differences were not statistically significant, it indicates a greater burden of structural inequities faced by Black participants. It is possible that a more detailed assessment of structural/economic disadvantage in this sample would reveal these differences, in addition to race-related stress, but this is speculative**.** We have previously found unique effects of racial discrimination on regions that are involved with processing of physical and emotional pain, converging around the anterior cingulate cortex.[26, 57, 58] The present race-related findings expand on prior data, indicating the possibility that this signature of amygdala-SSC connectivity in association with MIE in Black individuals could reflect the added burden of race-related stressors (from structural inequities to racial discrimination) on emotion processing-somatosensory pathways.

We did not find any correlations between MIE or MID and AS performance (error rate or response time), unlike prior studies of trauma (including racial trauma) and PTSD. [26] It is possible that the behavioral effects of MI on this attentional control task were too small to be detected in this sample. Another possible explanation for these null findings is that this task may not sufficiently capture/assay behavioral changes associated with moral injury. Given the involvement of the SSC in our findings, it is possible that a sensory processing or interoception task (including pain perception) could better assess these behavioral effects; this is worthy of future study. Additionally, we were surprised to find no significant associations between MID and amygdala functional connectivity. It is possible that our MI assessment was not sensitive enough to detect associations of distress related to MI and alterations in functional connectivity in emotion processing networks. Similarly, in a prior study, we found that MIE was significantly associated with past suicide attempt, whereas a non-significant trend was observed with MID[59]; taken together, these data may suggest the need for more granular assessment of MID in this sample of civilians with MI. It is also notable that the pattern of amygdala-SSC connectivity associated with MIE was driven by greater negative connectivity to neutral AS trials. These findings, while unexpected, may fit within a broader context of trauma research on neutral or ambiguous social stimuli indicating increased engagement in threat networks (including amygdala response) to these cues in trauma-exposed populations [60-64]; findings

could suggest that greater MIE affects attention to ambiguous stimuli, possibly leading to more effortful appraisal of the valence, meaning, and value of these stimuli, particularly in social contexts.

This study is not without limitations. As previously stated, we cannot make any claims about the functional consequences of this pattern of connectivity in association with MIE, including any attributions with pain or somatic complaints. Additionally, the MIESS-C subscales are not yet psychometrically established. Given that few studies have utilized measures that assess both exposure to morally injurious events and related distress [59, 65] and the utility of assessing both facets, validation of these subscales is warranted in future research. Further large-scale studies of moral injury in civilians that include measures of race-related trauma, pain (including affective experiences of pain), and interoception are needed to explore the potential intersections among these variables, as well as intersectionality with other salient variables, such as sex, or indices of structural racism, such as income, employment, and area deprivation. It is important to note that race was used as a proxy for race-related inequities and stress, given that we had insufficient data on race-related stress measures to perform meaningful statistical analyses. However, Black participants reported receiving more disability support and less private insurance support than White participants, revealing greater societal inequities faced by Black participants. This could be an indicator of elevated allostatic load, which, in turn may contribute to vulnerability for adverse physical and mental health outcomes after exposure to potentially morally injurious events. Further, we used an affective attentional control task during fMRI in combination with a self-report measure of MI; the former has clear limitations in assessing the construct of MI. Script-driven imagery of morally injurious events may be a better fMRI assay for this construct, similar to prior studies [14, 15]. Lastly, our sample size was limited, which similarly limited statistical power to test further interactions with racial discrimination or other types of trauma.

To our knowledge, this is the first investigation of neural correlates of MI in a chronically trauma-exposed civilian population—and also the first to test for interactions with race. Our data extend prior psychophysiological research on moral injury and autonomic dysregulation,[9] revealing that MIE is also linked to disrupted amygdala-SSC connectivity during performance of an affective attention task. The findings from this study suggest that greater exposure to morally injurious stressors could impact the emotional evaluation of incoming afferent signals. This could contribute to the emergence of somatic manifestations of distress, including chronic pain-related disorders, as well as functional impairment related to these conditions. These associations may be particularly potent for Black individuals, who are disproportionately burdened with potentially morally injurious race-related stressors. This intriguing pattern of findings suggests that MI merits further investigation as a distinct construct in neurobiological studies of trauma, indicating a potential mechanistic pathway for intervention.

Table 1. Descriptive & Clinical Characteristics N=48

	% (N)
Sex assigned at birth	
Female	93.8 (45)
Male	6.3 (3)
Race	
African American/Black	43.8 (21)
White	37.5 (18)
Hispanic/Latinx	10.4 (5)
Mixed	4.2 (2)
Asian	2.1 (1)
Other	2.1 (1)
Education Level	
Less than 12th grade	6.3 (3)
12th grade/High school graduate	8.3 (4)
Some college or technical school	33.3 (16)
Technical school graduate	6.3 (3)
College graduate	22.9 (11)
Graduate school	22.9 (11)
Current Employment Status	
No	37.5 (18)
Yes	62.5 (30)
Household Monthly Income	
$0 - $249	22.9 (11)
$250 - $499	6.3 (3)
$500 - $999	10.4 (5)
$1,000 - $1,999	16.7 (8)
$2,000 or more	43.8 (21)
Major Depressive Episode*	
Current	37.5 (18)
Lifetime	87.5 (42)
Alcohol Use Disorder*	
Current	14.6 (7)
Lifetime	18.8 (9)
Substance Use Disorder*	
Current	16.7 (8)
Lifetime	22.9 (11)

	% (N)
Disability Support	
Yes	8.3 (4)
No	91.7 (44)
Health Insurance[1]	
None	12.5 (4)
Medicaid/Medicare	15.7 (5)
Private insurance	71.9 (23)

[1]Missing data on 16 participants

	Range	M (SD)
Age	18-56	30.56 (11.93)
MIESS-C Exposure	10-30	21.97 (4.66)
MIESS-C Distress	6-30	20.68 (5.55)
TEI Total	1-16	5.89 (3.32)
CTQ Total	27-98	54.77 (17.99)
CTQ Sexual Abuse	5-23	11.29 (6.09)
CTQ Physical Abuse	5-21	8.98 (3.99)
CTQ Emotional Abuse	5-25	13.41 (5.39)
CTQ Emotional Neglect	5-25	12.48 (4.92)
CTQ Physical Neglect	5-17	8.65 (3.26)
PCL-5 Total[2]	17-73	42.51 (14.33)
PCL-5 Cluster B[2]	2-18	9.74 (4.49)
PCL-5 Cluster C[2]	0-8	5.46 (2.16)
PCL-5 Cluster D[2]	3-27	14.97 (5.90)
PCL-5 Cluster E[2]	6-21	12.33 (4.40)
MPSS Total[3]	23-50	31.19 (7.05)
Affective Stroop		
Percent error, neutral distractor trials	0.00-0.53	0.06 (0.11)
Percent error, positive distractor trials	0.00-0.53	0.07 (0.11)
Percent error, threat-relevant distractor trials	0.00-0.63	0.07 (0.12)

MIESS-C=Moral Injury Exposure and Symptom Scale for Civilians
TEI=Traumatic Events Inventory
CTQ=Childhood Trauma Questionnaire
PCL-5=PTSD Symptom Checklist DSM-5
MPSS= Modified PTSD Symptom Scale
CAPS-5=Clinician Administered PTSD Scale DSM-5
[2]Missing data on 9 participants
[3]Missing data on 27 participants
*No differences in MIESS-C scores observed between participants with and without current and lifetime diagnoses.

Table 2. *Correlations of Moral Injury with Age, Trauma, PTSD Symptoms and Affective Stroop Task Performance*

	MIESS-C Distress	Age	CTQ Total	TEI Adult Total	PTSD symptoms	AS percent error, neutral distractor	AS percent error, positive distractor	AS percent error, trauma distractor
MIESS-C Exposure	0.80 (p<.001)	-0.26 (p=.072)	0.43 (p=.003)	0.41 (p=.004)	0.51 (p<.001)	-0.27 (p=.063)	-0.24 (p=.104)	-0.23 (p=.113)
MIESS-C Distress		-0.11 (p=.445)	0.33 (p=.022)	0.42 (p=.003)	0.51 (p<.001)	-0.21 (p=.239)	-0.14 (p=.254)	-0.15 (p=.221)

Figure Captions.

Figure 1. Moral injury exposure is significantly associated with increased amygdala-somatosensory cortex connectivity during attention to threat-relevant versus neutral affective stroop distractor trials.

Figure 2. Race moderates associations between moral injury exposure and amygdala-somatosensory cortex functional connectivity. Data points represent functional connectivity values to threat-relevant versus neutral affective stroop trials. Blue markers denote Black participants; red markers denote white participants.

MIESS-C=Moral Injury Exposure and Symptom Scale – Civilian

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