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RESEARCH ARTICLE

Posttraumatic stress symptom severity is associated with impaired processing of emotional faces in a large international sample

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Abstract

Trauma exposure and posttraumatic stress symptoms (PTSS) are associated with biases in emotional face processing. Existing research has utilized a variety of methodological techniques to demonstrate hyperreactivity to threatening cues in posttraumatic stress disorder (PTSD; i.e., fearful faces), but studies to date have shown conflicting findings, including both increased and decreased time fixating on fearful faces. Moreover, the impact of PTSS severity on emotional face processing in the general population is unknown, as the generalizability of prior work is limited. The current study aimed to examine the associations between PTSS and sensitivity to detecting differences in fearful, angry, and happy faces in a large international sample. Participants were 1,182 visitors (M_{age} = 31.13 years, *SD* = 13.57, range: 18–85 years) to TestMyBrain.org who completed three emotion sensitivity tasks and the PTSD Checklist for *DSM-5*. The results indicated that higher PTSS scores were associated with poorer performance in detecting happiness, fear, and anger, $ps < .001$, with the largest effect for fear, $f^2 = .06$, controlling for age and gender. Participants who experienced more recent and more direct trauma exposure displayed higher levels of PTSS, with a small but significant effect whereby more direct trauma exposure was associated with higher (i.e., better) scores for anger and fear, f^2s = .02. Women showed heightened sensitivity to detecting fear compared to men, $d = 0.17$. The present findings underscore the value of citizen science initiatives that allow researchers to obtain clinical data from diverse samples with a high degree of PTSS variability.

Trauma exposure and posttraumatic stress disorder (PTSD) symptoms are associated with biases in emotional face processing. Neuroimaging studies have shown associations between PTSD and amygdala hyperreactivity to threatening cues (i.e., fearful faces; Badura-Brack et al., 2018). Additionally, a combination of eye-tracking studies, attention orienting studies, and various experimental morphed face paradigms have shown that veterans with PTSD spend either more (Armstrong et al., 2013) or less (Beevers et al., 2011) time fixating on fearful faces and display an attention bias toward threatening faces (Fani et al., 2012). Despite this prior work, generalizability across studies is limited due to small sample sizes and specific cohorts (i.e., combat veterans, women only) as well as vastly different methodologies. From morphed and distorted face paradigms to neuroimaging studies, which use technologies including magnetoencephalography (MEG), functional magnetic resonance imaging (fMRI), and electroencephalogram (EEG), to eye-tracking studies and attention orienting paradigms, there is a lack of consensus in the field on the best way to investigate emotional face processing in individuals with PTSD and those with posttraumatic stress symptoms (PTSS). These different methodologies and samples have also led to problems in determining if emotional face processing biases occur across emotions or only for specific emotions, such as fear. Thus, there is still a gap in the field's understanding of how PTSS impact emotional face processing across emotions. This gap can be targeted by specifically measuring sensitivity to detecting differences in emotional faces among individuals with varying degrees of PTSS.

PTSD and fearful face processing

Hypervigilance is a symptom of PTSD that has been linked to changes in how one processes threats (i.e., fearful faces). PTSS have been associated with faster reaction times in identifying fearful faces, even among children, as shown in a series of studies using morphed and distorted face paradigms in a sample of maltreated youth (Masten et al., 2008). However, Poljac et al (2011) found that compared with healthy controls, participants with PTSD showed reduced recognition of fear and sadness during a morphed face task. Using MEG to compare combat veterans with and without PTSD, those with PTSD demonstrated more amygdala reactivity when processing threatening faces (Badura-Brack et al., 2018). In an fMRI study comparing combat-exposed veterans with PTSD, combat-exposed veterans without PTSD, and healthy controls, combat-exposed veterans showed more amygdala reactivity to all faces in an emotional face processing task compared to healthy controls; furthermore, participants in the PTSD group demonstrated the highest level of amygdala reactivity when viewing fearful faces (Simmons et al., 2011). In another fMRI study, researchers found evidence of reduced amygdala activation while viewing fearful faces, which corresponded with the successful treatment of PTSD (Mahabir et al., 2015). Thus, considering emotional face processing changes after trauma exposure may have important treatment implications for PTSD.

In addition to the morphed faces and neuroimaging studies, eye-tracking and attention bias paradigms, including dot-probe studies, have also found a correlation between PTSD and fearful face processing. In a study comparing veterans with PTSD, veterans without PTSD, and healthy nonveteran controls with no diagnoses, Armstrong et al. (2013) observed that veterans with PTSD spent the most time fixating on fearful and disgusted faces. The authors suggested that longer time spent looking at fearful faces (i.e., threat cues) could represent a symptom of PTSD or cognitive vulnerability that might increase the risk for the development of trauma-related psychopathology. The findings from dot-probe–oriented studies have also demonstrated associations between psychopathology and extended fixation times on fearful faces or threatening cues. For example, Fani et al. (2012) observed an attention bias toward threatening faces among participants with PTSD, leading them to conclude that abnormalities in fear-loading can create and maintain PTSD symptoms. However, these findings on attention bias have been contradicted by other studies that have reported decreased time focusing on fearful faces among veterans with war zone stress exposure (Beevers et al., 2011). More specifically, Beevers and colleagues (2011) found that in veterans with war zone stress exposure, shorter mean fixation time in viewing fearful faces predicted higher levels of PTSD symptom severity, whereas more total fixation time and longer fixations on sad faces predicted higher levels of depression. Additionally, the authors of a study that morphed the intensity of emotional faces along a scale found that compared with healthy controls, participants with PTSD had reduced accuracy and sensitivity toward faces containing fear or sadness (Poljac et al., 2013).

PTSD and angry face processing

In addition to the established connection between PTSS and the processing of fearful faces, there is also an association between PTSS and angry face processing. One study found a "backward blink effect" with angry faces in adults with PTSD (Schönenberg & Abdelrahman, 2013), which occurs when two stimuli are shown and the second stimulus (i.e., angry faces) negatively affects the recall of the first stimulus. This suggests that PTSD symptoms are related more to attentional interference than attention facilitation toward threats (Schönenberg & Abdelrahman, 2013). Furthermore, using EEG, one study found that late positive potential (LPP), an event-related potential that reflects facilitated attention toward emotional stimuli, was related to PTSS with regard to viewing angry faces specifically (DiGangi et al., 2017), suggesting that individuals with PTSD actively avoid looking at angry faces. These results were replicated and clarified by another study, which showed that the more severe PTSS, the greater the LPP effect (Macatee et al., 2020). In a recent study examining childhood maltreatment and PTSD and interpretations of neutral facial expressions, participants with PTSD did not perform any differently than control groups, but higher levels of childhood emotional and sexual abuse, as well as physical neglect, were linked to a more negative interpretation of neutral facial expressions (Pflatz et al., 2019). Thus, there may be differences in emotional face processing based on the level of trauma exposure or type of trauma experienced.

PTSD and happy face processing

To the best of our knowledge, limited research on PTSS and happy face processing exists, as much of the literature to date has focused on fear and anger. In a recent study, Kaiser and colleagues (2020) examined attention for threat via a dot-probe task in patients with comorbid PTSD and borderline personality disorder. The results did not show biased attention for happy faces at any stage of information processing. In their study of reward processing and neural networks in PTSD, Felmingham et al. (2014) showed that participants with PTSD rated happy facial expressions as less intense than trauma-exposed controls. Moreover, the authors found that participants with PTSD demonstrated lower activation in the ventral striatum and a trend for reduced left amygdala activation when presented with happy faces, which may be associated with symptoms of emotional numbing. In another study, individuals with PTSD, cumulative trauma exposure, and dissociation showed impaired recognition of positive emotions during an emotion recognition task compared to traumatized healthy controls and nontraumatized healthy controls (Passardi et al., 2018). In a separate study using the Reading the Mind in the Eyes Task (RMET), a theory of mind task, women with PTSD stemming from childhood trauma demonstrated slower RMET reaction times to both positive and negative emotionally valenced states (Nazarov et al., 2014). Most recently, a review of PTSD and reward functioning (Seidermann et al., 2021) highlighted how most research on PTSD has focused on fear, stressing the need for further study of the complex association between reward system functioning and trauma exposure.

Emotional face processing and PTSS: What is still unknown

Although methodological and geographic limitations have limited the understanding of how PTSS and emotional face processing occurs at scale, web-based approaches offer an alternative source of information to traditional lab-based paradigms, which are expensive and potentially burdensome to patients. A growing trend to study emotional face processing using online tasks allows for larger, more diverse samples and, thus, a better understanding of how emotional face processing and PTSS occur across the globe.

Current study

Prior research, including much of the previously described work, has established brain region abnormalities in PTSD, the variety of uses for emotional face processing paradigms for better understanding PTSD, and some purported mechanisms that contribute to the development and maintenance of PTSD symptoms. However, much of this prior work has suffered from a lack of generalizability, with many studies severely limited in sample size and population demographic characteristics. Furthermore, many of these studies have reported results that primarily revolve around fear or anger, with little known about other emotions, such as happiness. The current study sought to expand the literature on the association between trauma exposure and emotional face processing and increase generalizability by recruiting a diverse international sample of adults with a wide variety of PTSS. More specifically, we aimed to target the gaps in knowledge on emotion processing and PTSS through a high-powered and more diverse sample than has been previously examined, while controlling for potentially confounding effects, such as age and gender. Finally, we used a relatively novel emotion sensitivity (ES) task that is response bias–free, allowing us to isolate and compare sensitivity for specific emotion categories (i.e., fear, anger, happiness). This approach enabled us to gain a more comprehensive understanding of true emotion processing difficulties that may be occurring in PTSD rather than effects due to the task itself. The ES task used in the present study, the Belmont Emotion Sensitivity Task (BEST), has been used previously in adults with generalized anxiety symptoms (Rutter, Scheuer, et al., 2019), depressive symptoms (Rutter et al., 2020), and dissociative identity disorder (Lebois et al., 2020), as well as among adults in the general population (Rutter, Dodell-Feder, et al., 2019), but the task has not been used in a sample of adults with PTSS.

The primary aim of the current study was to examine the associations between PTSS, as assessed using PTSD criteria outlined in the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-5*; American Psychiatric Association [APA], 2013), and sensitivity to detecting differences in fearful, angry, and happy faces in a large, international sample. We had two primary hypotheses. First, we predicted that in line with previous research, PTSS severity would be negatively related to performance in the emotional face processing task such that individuals with more severe PTSS would perform worse on an ES task, with poorer performance for each emotion category (i.e., fearful, angry, and happy faces; Armstrong et al., 2013; Badura-Brack et al., 2018; Felmingham et al., 2014). Second, we explored the associations between PTSS and both trauma recency and the level of trauma exposure. We hypothesized that participants who had been both more recently and more directly exposed to traumatic events would have lower scores across emotions an ES task, consistent with the previous finding that direct exposure and closer proximity to trauma can impact PTSD symptoms (May & Wisco, 2016).

METHOD

Participants and procedure

Participants were 1,182 visitors to TestMyBrain.org who completed three ES tasks and the PTSD Checklist for *DSM-5* (PCL-5; Weathers, Litz, et al., 2013) and provided demographic information. The TestMyBrain platform (see Germine et al., 2012) was approved by the Harvard Committee on the Use of Human Subjects. Individuals provided informed consent before taking part in the study. Participants who did not complete all three ES tasks and the PCL-5 were excluded from the present analyses, and those who did not endorse a *DSM-5* Criterion A traumatic event (APA, 2013) were given an alternate questionnaire and were not included in any analyses. Thus, there were no missing data.

Participants' ages ranged from 18 to 85 years ($M = 31.13$ years, $SD = 13.57$). The sample was predominantly female (60.0%), with 33.7% of participants identifying as male and 6.4% as genderqueer. The majority of the sample was of European descent (63.3%), followed by Asian (15.0%), African (7.5%), the Americas (3.1%), and the Pacific (0.9%); 4.5% of participants endorsed "uncertain" for this question. Most participants identified as non-Hispanic (80.0%) and were from English-speaking countries (70.1%). Additional demographic information is presented in Table 1. Data were obtained from December 2020 to April 2021.

TABLE 1 Participant demographic characteristics

Variable	*n*	%
Gender		
Female	709	60.0
Male	398	33.7
Genderqueer	75	6.3
Educational attainment		
Decline to answer	95	8.0
None	6	0.5
Middle school	40	3.4
High school	214	18.1
Some college	327	27.7
Technical school	68	5.8
College	242	20.5
Ethnicity		
European descent	748	63.3
Asian descent	177	15.0
African descent	88	7.5
Americas	37	3.1
Pacific Islander	10	0.9
Uncertain	53	4.5
Decline to answer	69	5.8
Geolocation		
Americas/Europe	901	86.3
Asia	143	13.7
Native language		
English	829	70.1
Not English	353	29.9

Note: $N = 1{,}182$.

Measures

ES

The Belmont Emotion Sensitivity Test (BEST; Rutter, Dodell-Feder, et al., 2019) is used to assess sensitivity with regard to detecting subtle differences in emotion intensity within an emotion category (i.e., anger, fear, or happiness). The BEST was designed to eliminate response bias–related confounds that are present in the existing emotional face–processing literature (see Rutter, Dodell-Feder, et al., 2019, for a review). Faces were drawn from the Karolinska Directed Emotional Faces (Lundqvist et al., 1998) database and morphed between any two of angry, happy, and fearful faces across a set of over 24 identities, creating three morphed continua per identity (Rutter, Dodell-Feder, et al., 2019; Rutter, Scheuer, et al., 2019). Facial expressions of the same individual with varying intensities of the different emotional facial expressions (i.e., anger, fear, or happiness) were morphed into a single image that was paired with another face of the same individual (see Figure 1). These images appeared next to each other, each showing an emotional expression of different intensities. Face pairs were selected from morphs between two emotional faces (i.e., anger, fear, or happiness) to ensure that judgments of the emotional intensity were related to judgments of a given emotion rather than general emotion intensity. Thus,

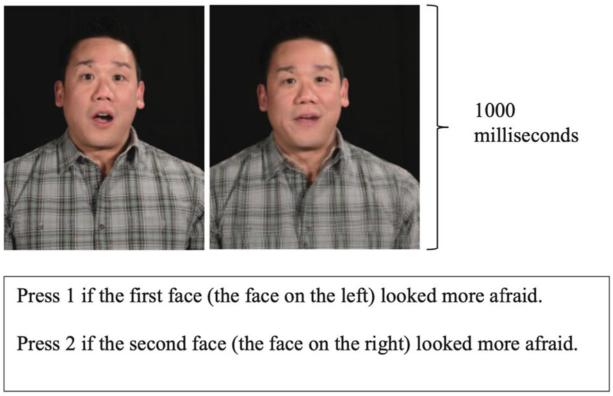

FIGURE 1 Belmont Emotion Sensitivity Test example trial. Note. The face pair shown above has been previously printed in Rutter et al. (2019); it is shown above is for illustration purposes only. The faces shown in the figure are from the Act Out for Brain Health database. Faces on the actual test, which are not pictured, were taken from the Karolinska Directed Emotional Faces (KDEFS) database (Lundqvist et al., 1998)

anger sensitivity, fear sensitivity, and happiness sensitivity were each assessed using subsets of 56 separate pairs of faces. For each subtest, participants were shown 28 female and 28 male face pairs, with each pair presented one at a time for 1000 ms. After 100 ms, the faces became shaded black squares, and participants were asked, "Which face is more angry?", "Which face is more fearful?", or "Which face is more happy?," depending on the emotion being assessed. Trials were ordered such that difficulty increased as the task progressed, with eight easy, 20 medium, and 28 hard trials per participant. For example, an easy anger trial may present a 70% difference along the morph continuum such that one face in the pair contains 90% of the angry face and 10% of the happy face, whereas the other face might include 20% anger and 80% happiness. The BEST was designed to eliminate response bias by relying on a forced-choice response format with counterbalancing trials for left versus right responses. Higher scores indicate more enhanced emotion perception skills (i.e., higher ES). A maximum score of 56 is possible for each emotion category. See Figure 1 for an example trial and Rutter et al. (2019) for a more detailed description of the BEST development.

PTSS

The PCL-5 (Weathers, Litz, et al., 2013) is a 20-item self-report measure that is used to assess both the presence and the severity of *DSM-5* PTSD symptoms. PCL-5 items are rated on a 5-point Likert scale ranging from 0 (*not at all*) to 4 (*extremely*), with a total possible score range of 0–80. Higher scores indicate more severe PTSD symptoms. The PCL-5 was designed to be multipurpose, including for quantifying and monitoring PTSD symptoms over time, screening individuals for PTSD, and making a provisional PTSD diagnosis. We used a version of the PCL-5 without a *DSM-5* Criterion A component, although this is also a limitation of the present study, as we did not have clinical interviewers or research staff to thoroughly assess Criterion A. The PCL-5 is not meant to be used as a standalone diagnostic tool; however, a cutoff score of 31–33 appears to be suggestive of a probable PTSD diagnosis across samples (Blevins et al., 2016; Bovin et al., 2016; Weathers, Litz, et al., 2013; Wortmann et al., 2016). In the present sample, internal consistency for the PCL-5 was excellent, Cronbach's $\alpha = .94$.

Data analysis

Data were analyzed in R Studio (Version 1.0.153). First, we confirmed that ES and PTSS both varied in the expected directions when considering age and gender. More specifically, based on prior work, we expected to observe a positive association between ES and age a negative association between ES and PTSS. Additionally, we hypothesized that PTSS severity would be higher in women compared with men and that women would outperform men on ES across emotion categories. Next, we examined differences in ES based on the binary PTSD diagnostic cutoff using *t* tests. Third, using linear regression, we expected a negative association between PTSS and ES after controlling for age and gender. To test our second hypothesis, we examined differences in ES based on the time since trauma (i.e., in the last month = 3, between 1–12 months ago = 2, 1–5 years ago = 1, and more than 5 years ago = 0) and level of trauma exposure (i.e., whether the traumatic event was experienced directly = 3, witnessed = 2, or learned about/exposed to details about = 1, and other = 0) using multiple regression. Our sample of 1,182 patients provided adequate power ($\beta = .80$) to detect effects of small to medium size (i.e., f^2 =.08), at an alpha level of .05, using multiple regression. For each major analysis, we used a conservative Bonferroni adjustment (p <.017) to correct for multiple comparisons across the three emotion categories.

RESULTS

The average PCL-5 score in our sample was 28.52 (*SD* = 17.82; range: 0–80). Average ES scores, calculated as the total correct out of 56 face pairs, were 47.29 (*SD* = 5.37, range: 18–56) for anger, 46.54 (*SD* = 5.72, range: 22–56) for fear, and 47.26 (*SD* = 4.00, range: 20–56) for happiness.

Based on a series of Welch's t tests, ES scores significantly differed by emotion category, with the highest scores for anger compared to fear, $t(2{,}353) = 3.28$, $p = .001$, $d = 0.13$, and happiness, $t(2{,}184) = 0.12$, $p = .900$. Although the difference between anger and happiness scores was not significant, happiness scores were significantly higher than fear scores, $t(2{,}114) = -3.57$, $p < .001$, $d = 0.15$, indicating that participants' sensitivity to detecting fear was lower when compared with both happiness and anger. Using Welch's t tests to compare female participants to male participants on ES scores, female participants had significantly higher (i.e., better) scores for fear, $t(785) = 2.76$, $p = .006$, $d = 0.17$. Of note, we did not include genderqueer individuals in our statistical comparisons of male and female participants. There were no significant differences between happiness scores and anger scores between female and male participants, $ps = .458$–$.981$. Female participants reported significantly more severe PTSS than male participants, $t(822) = 2.58$, $p = .010$, $d = 0.16$.

Using PCL-5 scores of 33 or higher as our binary cutoff, 39.9% of the sample met the criteria for a provisional PTSD diagnosis and 60.1% did not. The results of Welch's t tests showed that participants in the provisional PTSD group had significantly lower (i.e., worse) ES scores than the subclinical group across emotion categories, anger: $t(966) = 2.58$, $p = .010$; fear: $t(966) = 2.33$, $p = .020$; happiness: $t(880) = 3.98$, $p < .001$.

To further examine the association between PTSS and ES scores, we estimated a series of regression models. First, we tested whether PTSS severity was negatively associated with age and found that they did, indeed, decline significantly with age, $\beta = .11$, $R^2 = .01$, $F(1, 1{,}180) = 13.44$, $p < .001$. We then examined the association between age and ES and found significant effects for all emotion categories: anger: $\beta = -.16$, $R^2 = .02$, $F(1, 1{,}180) = 30.23$, $p < .001$; fear: $\beta = -.15$, $R^2 = .02$, $F(1, 1{,}180) = 25.38$, $p < .001$; happiness: $\beta = -.11$, $R^2 = .01$, $F(1, 1{,}180) = 14.74$, $p < .001$. Given the significant associations between age, gender, and PTSS, we controlled for age and gender in all subsequent analyses, using age, age^2, and gender as covariates in our regressions. Consistent with our hypotheses, higher levels of PTSS were associated with reduced ES for all emotion categories, anger: $\beta = -.12$, model $R^2 = .05$, $F(4, 1{,}102) = 13.70$, $p < .001$; fear: $\beta = -.12$, model $R^2 = .06$, $F(4, 1{,}102) = 16.09$, $p < .001$; happiness: $\beta = -.15$, model $R^2 = .04$, $F(4, 1{,}102) = 10.10$, $p < .001$ (see Figure 2). In other words, higher levels of PTSD symptom severity were associated with poorer performance in detecting fear, anger, and happiness, and this effect held true regardless of age. All tests survived correction for multiple comparisons, but effect sizes were relatively small, with the largest effect for fear, $f^2 = .06$, followed by anger, $f^2 = .05$, and happiness, $f^2 = .04$.

To examine the associations between PTSS and ES scores and both time since trauma and level of trauma exposure, we coded how long ago each participant experienced their index traumatic event and how they experienced the event (i.e., directly experienced, witnessed, learned about, or exposed to details) on ordinal scales, with higher scores indicating more recent and direct trauma exposure, as previously described. Not surprisingly, both trauma recency and level of exposure were positively associated with total PTSS, recency: $\beta = .16$, exposure proximity: $\beta = .16$, model $R^2 = .05$, $F(2, 1{,}179) = 30.91$, $p < .001$. Next, we examined whether trauma recency and level of exposure impacted ES scores by regressing these scores onto ES while controlling for PTSS. Time since trauma was not associated with ES scores for any emotion category; however, for anger, $\beta = .06$, $R^2 = .01$, $F(3, 1{,}178) = 5.19$, $p = .001$, and fear, $\beta = .10$, $R^2 = .02$, $F(3, 1{,}178) = 6.35$, $p < .001$, the level of trauma exposure a participant experienced was significantly associated with scores such that higher (i.e., better) ES scores were associated with closer proximity to traumatic events (i.e., directly experiencing vs. witnessing or learning about an event). All tests survived corrections for multiple comparisons, but effect sizes were small.

DISCUSSION

The present study recruited participants from across the world via the citizen science initiative TestMyBrain.org to investigate the effects of PTSS on emotional face processing. Given the large, diverse sample of participants and psychometrically validated ES task, which was designed to reduce response bias, the results yielded several contributions to the literature. In summary, higher levels of PTSS were associated with lower ES performance across emotions (i.e., fear, anger, and happiness) and across the lifespan. Participants who experienced more recent and more direct trauma exposure displayed higher levels of PTSS. Trauma recency did not impact ES scores for any category, but there was a small, significant effect whereby more direct trauma exposure was associated with higher ES scores for anger and fear, consistent with the finding that one's level of exposure and proximity can affect PTSD risk (May & Wisco, 2016) but inconsistent with the rest of our findings that more severe PTSS were associated with lower ES performance. There is no clear reason why participants with more direct trauma exposure had slightly higher ES scores for anger and fear, as this was an unexpected finding. Potentially, the higher ES scores for anger and fear can be linked to the concept of posttraumatic growth (see Wozniak et al., 2020), which posits that individuals who have high levels of direct exposure to traumatic events may become better at detecting anger and

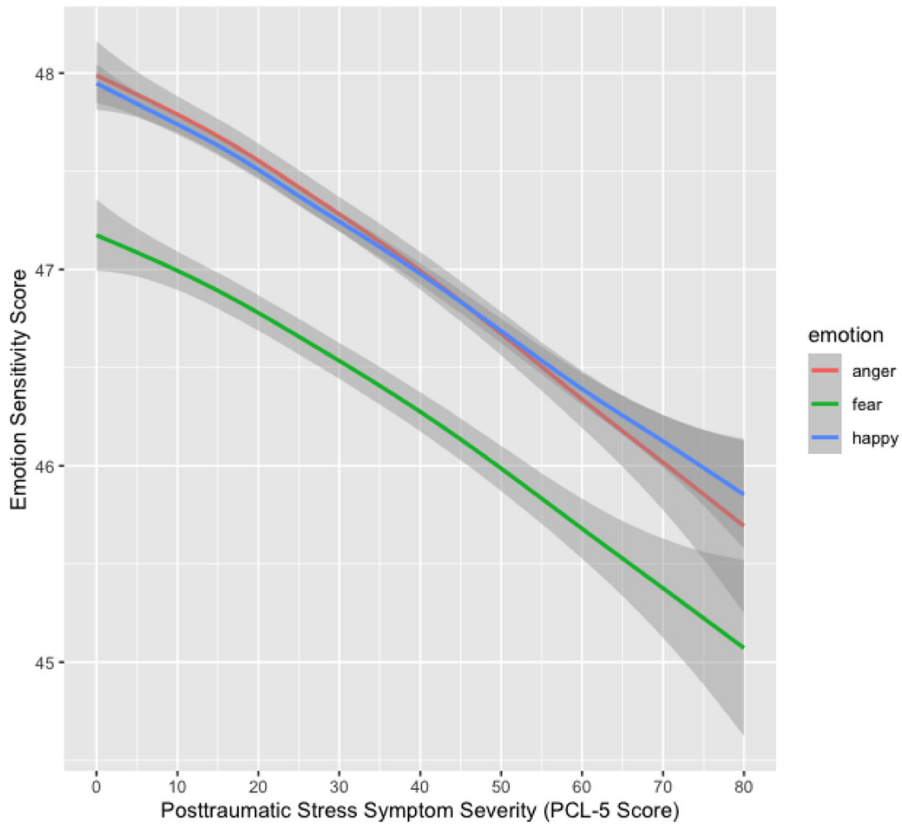

FIGURE 2 Association between posttraumatic stress symptom severity and emotion sensitivity scores. Note. Gray bars represent 95% confidence intervals. PCL-5 = PTSD Checklist for *DSM-5*

fear to protect themselves from future trauma exposure or because it benefits them to read emotions quickly in their lives. This is speculative, however, and more research is needed to clarify the reasons for this finding. To the best of our knowledge, the effect of trauma proximity has been studied primarily in campus shootings, and the literature is lacking on the effects of trauma proximity and posttraumatic growth with respect to different trauma types. Overall, participants demonstrated the highest scores for recognizing anger, followed by happiness and, finally, fear. The finding that, on average, ES scores were lowest for fear relative to other emotions is closely in line with prior studies showing biases in processing fear in PTSD, including enhanced gaze on fearful faces (Armstrong et al., 2013), structural abnormalities in the medial prefrontal cortex (Phillips et al., 2003), and increased amygdala activation in response to the nonconscious processing of fear stimuli in PTSD (Bryant & Guthrie, 2007).

We observed the largest effect for fear, which provides additional support for the idea that emotion processing of fear versus anger may elicit different responses in patients with PTSS. Indeed, although facial expressions of fear and anger have been used interchangeably as threatening stimuli, there is existing evidence that these facial expressions can elicit different responses. Whereas fear conveys danger in external surroundings, anger signals a more proximal and direct threat (e.g., Davis et al., 2011; Taylor & Whalen, 2014). In a recent study testing responses to angry and fearful expressions in a modified Eriksen flanker task, PTSD patients and military controls showed nearly identical interference effects on fearful and neutral target trials (Ashley & Swick, 2019). However, post hoc testing showed that PTSD patients responded faster than controls to congruent angry faces (i.e., target and flanker faces both angry) relative to controls. These results may suggest that PTSD patients are more primed to respond to angry faces relative to fearful ones. The authors note that this should be interpreted with caution, and further study is needed. Indeed, the relatively small sample size and lack of consensus among researchers on task choice is a limitation of this literature.

Interestingly, despite higher levels of PTSS in female participants relative to male participants in the present sample, there were no significant differences in ES that held true across emotion categories. However, women had significantly higher ES for fear than men. The finding that women showed heightened sensitivity to detecting fear was also demonstrated in a prior study investigating ES in generalized anxiety disorder (Rutter, Scheuer, et al., 2019). Thus, the current study adds further support to the existing literature on sex differences in emotion perception (McClure, 2000) and is consistent with an EEG study showing larger responses to subthreshold fearful faces in an event-related potential design (Lee et al., 2017). However, even if a specific gender effect for processing fear exists, the effect size is likely small and requires further study.

Notably, the present sample had higher rates of provisional PTSD than what is seen in the general United States population, as based on the National Comorbidity Survey and National Comorbidity Survey Replication (Kessler et al., 1995, 2005). Initial research on the validity of the PCL-5 indicates that the population and purpose of the screening may warrant different cutoff scores, and additional research is needed (Weathers, Litz, et al., 2013). Cutoffs derived from nonanonymous samples may not generalize, as anonymous samples tend to more openly and honestly report symptoms. Another potential reason for this discrepancy is that participants may have felt more comfortable disclosing details of their trauma exposure in the present study because of the way in which they were reporting this information, that is, anonymously and not tied to a specific study site or type of treatment. Furthermore, findings from a recent study indicated that among participants who completed both self-report questionnaires and structured clinical interviews to determine PTSD diagnosis, participants were much more likely to meet the criteria for a PTSD diagnosis based on the self-report, with only one participant qualifying for a diagnosis based on the clinical interview (Sumpter & McMillan, 2005). It is possible that a self-report questionnaire is not best suited to accurately capture PTSS, as the PCL-5 is recommended to be used in conjunction with clinical interview and clinical judgment (Weathers, Litz, et al., 2013). In fact, the PCL-5 may be sensitive to detecting responses to stress that are not consistent with reexperiencing symptoms, avoidance and numbing symptoms, cognitive symptoms of PTSD, or hyperarousal. Thus, an additional study that examines ES in PTSD in a sample that has been diagnosed with PTSD by trained clinicians is warranted.

The present results should be considered in the context of several limitations. First, although the observed effect sizes were significant and survived tests of multiple comparisons, they were small, and replication is recommended. Next, although we asked about different qualifiers for a *DSM-5* PTSD Criterion A traumatic event (e.g., how direct exposure was, whether it involved death, the threat of death, serious injury, bodily harm, or sexual violation), we did not have a question regarding the specific type or types of traumatic event participants considered to be the cause of their PTSS. In future work, it is recommended to have a more in-depth assessment of *DSM-5* Criterion A, even if the data are self-report. A self-report measure of trauma exposure, such as the Life Events Checklist for *DSM-5* (Weathers, Blake, et al., 2013), paired with the PCL-5 with may provide sufficient detail to determine whether a traumatic experience meets Criterion A, although, ideally, an assessment of Criterion A would be done by a trained clinician; thus, we were limited by the self-report nature of our data. Additionally, because it is unclear why our sample demonstrated higher PTSD prevalence than expected given PTSD rates in the general population, participants may not have read what a Criterion A trauma was and filled out the PCL-5 based on current feelings of stress. It is noteworthy that these data were collected amid the worldwide COVID-19 pandemic, so it is possible that participants were reporting based on higher rates of general distress. Moreover, there is ample reason to believe that trauma type impacts the development of PTSD, as a recent study showed that war-related experiences compared to adverse childhood experiences were independently associated with the development of lifetime PTSD (Castro-Vale et al., 2020). Additionally, although included anger, fear, and happiness in our assessment of ES, we did not include sadness, disgust, or surprise. As a result, there is a potential for other emotional differences that we did not examine.

Despite these limitations, to our knowledge, the present study was the first to date to examine the association between PTSS and ES. The study expands upon prior research in this area by its inclusion of a diverse, international sample. Moreover, we tested ES for three emotion categories, including happiness in addition to fear and anger, which are more typically examined in relation to PTSD. In addition to the present study, the BEST task is also being used in a multisite national study examining longitudinal responses to trauma (McLean et al., 2020).

Our findings demonstrated an association between PTSS severity and ES performance across emotions (i.e., fear, anger, happiness) after controlling for age and gender. More specifically, higher levels of PTSS were associated with poorer performance in detecting happiness, fear, and anger, *p*s $< .001$, with the largest effect for fear. Future researchers should investigate differences in emotional face processing and responding to traumatic experiences based on how distal (e.g., witnessed or heard about an event) or proximal (e.g., directly experienced an event) the exposure was based on the finding of an association between more direct exposure and enhanced sensitivity to detecting fear and anger. It is also important to collect information on what trauma types participants have experienced. Furthermore, there are a wide variety of tasks that researchers have employed to test emotional face processing. The field would benefit from a more standardized approach using the best combination of PTSD assessments; clinical information, including assessment of *DSM-5* Criterion A; self-report; and emotional paradigms. Additionally, although the literature includes copious research spanning several decades demonstrating that emotions are similar across cultures (Ekman & Friesen, 1972; Izard, 1994), there has been some debate if basic emotions are truly universal (Lim, 2016; Russell, 1994), and future research on PTSD and emotion processing should directly examine cultural factors. Using multiracial faces for emotion stimuli is recommended. Finally, future researchers should consider the psychometric properties of the emotional paradigms they are using and be open to citizen science initiatives, such as TestMyBrain.org, that allow scholars to obtain clinical data from large, diverse, nonclinical samples.

OPEN PRACTICES STATEMENT

The study reported in this article was not formally preregistered. Neither the data nor the materials have been made available on a permanent third-party archive; requests for the data or materials should be sent via email to the lead author at larutter@iu.edu .

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