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The Role of Negative Affect in the Association between Attention Bias to Threat and Posttraumatic Stress: An Eye-Tracking Study

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Abstract

Threat-related attention biases have been implicated in the development and maintenance of PTSD symptoms. Research examining mechanisms through which threat-related attention biases are associated with PTSD is scarce. Negative affect, a transdiagnostic risk factor for many types of psychopathology, is one potential mechanism that has yet to be examined. Thus, the present study ($n = 92$) tested the indirect effect of attention bias on PTSD via negative affect using rigorous eye-tracking methodology in a sample of urban-dwelling, trauma-exposed African-American women. We found support for the hypothesis that attention bias toward threat was indirectly associated with PTSD symptoms through increased negative affect. These results suggest that negative affect may be an important etiological process through which attention bias patterns could impact PTSD symptom severity. This finding is particularly important since negative affect can be directly addressed in the context of treatment. Implications for psychological and pharmacological therapeutic interventions targeting threat-related attention biases and negative affect are discussed.

Keywords

attention bias; eye-tracking; PTSD symptoms; negative affect

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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1. Introduction

Threat-related attention biases have been implicated in the development, etiology, and maintenance of a wide range of psychopathology (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). The nature of this bias has been characterized as both attention toward threat (Lazarov et al., 2019) as well as avoidance of threat (Cisler, Bacon, & Williams, 2009). Understanding this bias as it pertains to PTSD is especially important given the significant functional impairment associated with this diagnosis (Westphal et al., 2011). Given the heterogeneous symptomatology of posttraumatic stress disorder (PTSD), including both over-engagement with threat (e.g., intrusive symptoms) and intentional avoidance of threat (i.e., avoidance symptoms), it is important to develop a clearer understanding of why different types of attention bias patterns (i.e., approach, avoid threat) are associated with PTSD symptoms. Identification of attention bias patterns in the context of PTSD can contribute to the development of novel or augmented psychological and pharmacological therapeutic interventions targeting threat-related attention biases (Lazarov et al., 2019).

Recent meta-analyses and reviews of eye-tracking studies measuring attention bias show strong support for attention toward threat in individuals with PTSD, but weak evidence of avoidance of threat (Armstrong & Olatunji, 2012; Lazarov et al., 2019). Importantly, associations between attention bias patterns and individual symptom clusters of PTSD have not been examined. Despite consistent evidence that attention toward threat is associated with PTSD and other varied negative mental health outcomes (Bar-Haim et al., 2007), the processes through which this impairment leads to psychopathology remain unclear (Richards, Benson, Donnelly, & Hadwin, 2014).

One important factor that may play a role in attention biases' associations with PTSD is negative affect, or the tendency to experience negative emotions such as fear, guilt, and anger (Post et al., 2011). The integrative model of threat processing in the context of general anxiety proposes that impaired ability to "override" attention to threat (and consequent sustained processing of threat) may lead to sustained negative arousal (Bar-Haim et al., 2007). This model is consistent with that of impaired fear inhibition in PTSD, which has been conceptualized as deficits in the ability to suppress a fear response in safe conditions (Jovanovic et al., 2010, 2009). Reactivity to threatening stimuli may overload the prefrontal cortex to the point of interfering with the capacity to inhibit amygdala activity (Jovanovic & Ressler, 2010). Thus, impaired fear inhibition may function by increasing attention to threat in ways that maintain engagement (and prevent disengagement) with threatening stimuli. Importantly, one downstream consequence of over-engagement of threat is that it may increase the frequency of experiencing negative emotional reactions (i.e., negative affect; Lazarov et al., 2019). Thus, a key process in the relationship between attention to threat and PTSD symptom severity is negative affect.

The relation between attention biases and negative affect has been well documented in cross-sectional designs with healthy adults (Oehlberg, Revelle, & Mineka, 2012; Onie & Most, 2017). There is also evidence that attention biases have a causal effect on negative emotions. For example, in a study that experimentally manipulated attention bias in college students, Mathews & MacLeod (2002) found that attention to negative information resulted in

increases in negative mood. Although this effect has not been replicated with manipulation of attention away from threat, there is evidence from ecological momentary research that avoidance behavior is also associated with subsequent negative affect (Machell, Goodman, & Kashdan, 2015). Very few studies have examined the association between attention bias and negative affect in clinical samples, for whom these processes may be especially impairing.

Because negative affect contributes to the development of psychopathology (Böhnke, Lutz, & Delgadillo, 2014; Joiner & Lonigan, 2000) and has been identified as a “core” transdiagnostic factor in the structure of psychopathology, including PTSD, (Kotov et al., 2017; Post et al., 2011), it is critical to better understand the role it might play in the relation between attention bias patterns and PTSD. Research has shown that higher levels of negative affect may increase risk for the development of PTSD (Weems et al., 2007) and may also maintain symptoms (Tull, Jakupcak, McFadden, & Roemer, 2007). However, to our knowledge, no studies have examined the role of negative affect in the association between attention bias to threat and PTSD symptoms. This gap in the literature obstructs our ability to understand the processes through which attention bias patterns – and attention toward threat in particular – may play a role in PTSD symptoms among traumatized individuals.

Given that African Americans are more likely to meet criteria for PTSD compared to other racial and ethnic minorities groups and are often underrepresented in studies, research on attention bias patterns and PTSD symptoms in this group is especially important (Roberts, Gilman, Breslau, Breslau, & Koenen, 2011). Furthermore, there is evidence that women and individuals with limited socioeconomic means are particularly likely to be exposed to trauma and to develop PTSD (Golin et al., 2016). Thus, understanding attention bias patterns (e.g., individuals with a bias toward threat vs. away from threat) and what processes may contribute to such patterns at the intersection of race, gender, and socioeconomic status contributes to our understanding of PTSD in a particularly vulnerable population.

To address these gaps in the literature and build on the field’s growing understanding of attention bias patterns in PTSD, the goal of the present study was to examine the direct and indirect effects of attention bias on PTSD through negative affect in a sample of trauma-exposed, African-American women recruited from an urban public hospital serving primarily low-income individuals. This was done using rigorous eye-tracking methodology, which, compared to behavioral measures (e.g., dot probe) offers the capacity for researchers to directly assess, rather than infer, allocation of attention without the noise introduced by other processes (e.g., distal motor responses; Mele & Federici, 2012). Our main hypothesis was that attention bias type (i.e., attention toward threat, attention away from threat) will predict PTSD symptoms both directly and indirectly, through its association with negative affect. More specifically, attention toward threat will be associated with greater PTSD symptoms (compared to avoidance or no bias) via negative affect. Because there is limited empirical research on how these patterns may differ based on specific PTSD symptom clusters, we took an exploratory approach and replicated our analyses for each symptom cluster (hyperarousal, avoidance, anhedonia/numbness, intrusions) to examine the possibility of unique patterns of association among attention biases, negative affect, and PTSD symptom clusters.

2. Methods

2.1 Procedure

Participants were drawn from an ongoing study of risk factors for the development of PTSD in a low socioeconomic status, primarily African American, urban population (see Gillespie et al., 2009 for a full description of study procedures). Participants were recruited from waiting rooms in the gynecology and primary care medical (non-psychiatric) clinics at Grady Memorial Hospital, a publicly funded hospital in Atlanta, Georgia and approached at random. To be eligible for participation, subjects had to be at least 18 years old, not actively psychotic, and able to give informed consent.

If willing to participate, individuals signed the informed consent approved by the Emory IRB and the Research Oversight Committee of Grady Memorial Hospital, and an initial interview was administered with questionnaires regarding trauma history and psychological variables was conducted. Trained research assistants administered this interview (approximately 45–75 minutes depending on trauma history) in the waiting rooms of Grady Memorial Hospital. All participants were compensated for their time. A subset of participants completed the behavioral task with eye tracking methods during follow-up visits at the GTP laboratory located on the Grady Hospital campus from 2015 to 2016. Participants included in the present study were recruited for the behavioral task during a visit to finish the original interview or to complete a follow-up clinical interview as part of other ongoing research studies in the laboratory; those studies included a study of intergenerational trauma risk with mothers and their 8-to-12-year-old children and a study of women with Type II diabetes (and healthy controls). Only individuals with complete data from the initial interview and eye tracking task were included in the present analyses. The task took approximately 15 minutes. A subset of participants from the current study were included in a separate paper (Powers et al., 2019).

2.2 Participants

The final sample consisted of 92 women between the ages of 18 and 64 ($M = 40.02$, $SD = 11.32$). A total of 106 women completed the study, but 12 participants were excluded due to missing data on a key variable and 2 participants were excluded due to having an outlier score on the dwell measure (see below). The subjects were primarily African-American (95.7%) or mixed race (4.3%). The majority of participants were unemployed (68.6%) and 77.4% had a household monthly income of \$1,999 or less. Education level of participants was as follows: 17.1% had less than a 12th grade education, 31.9% completed high school, 27.7% completed at least some college or technical school, and 17.0% graduated from college or technical school. All participants in the study met criteria for at least one Criterion A traumatic event as determined by the DSM-5 (APA, 2013) and reported experiencing an average of almost four different traumas. See Table 1 for more specific demographic information.

2.3 Measures

2.3.1 Measure of attention bias using eye tracking—Participants completed a version of the modified dot probe task (Mogg, Bradley, De Bono, & Painter, 1997) that

included 80 trials. In each trial, a pair of face photographs (both of the same actor) was presented for 5000 msec. The task stimuli included photographs of African American and Caucasian men and women (Schmidt, Davis, & Tone, 2012). After the offset of each face pair, an asterisk was presented in the location that one of the faces had occupied. To help maintain continued participant engagement, participants were asked to determine as quickly as possible, with a forced-choice button press response, whether the asterisk appeared on the left- or right-hand side of the screen. Face pairs included either one face displaying an emotional expression (either threatening or happy) and the other a neutral expression or two neutral faces. The probe appeared on the left or right side of the screen an equal number of times. During half of the neutral-neutral trials, the probe appeared on the left, and during the other half, it appeared on the right. **Eye tracking:** All participants placed their head on a chin rest, directly in front of the computer monitor. Pictures were displayed on the screen in front of them. All pictures were black and white. The eye tracking procedure began with a calibration/validation sequence during which participants had to follow a dot presented randomly at nine different locations on the screen with their eyes. The accuracy of the calibration was checked between each trial and the participant was recalibrated if the system noted an error. Once the calibration was completed, the dot probe task began. Line of visual gaze was assessed using a remote optics eye tracking system Model R6 from Applied Science Laboratories (Bedford, MA). Direction of gaze, measured with x and y coordinates, was sampled every 16.7 msec (60 Hz), producing 299 gaze location measurements for each 5000 msec trial. Eye movements that were stable for more than 100 msec within 1° of visual angle were classified as a fixation. An individual dwell was defined as the time during which a contiguous series of 1 or more fixations remains within an Area of Interest (AOI), regardless of how many individual fixations this action comprises.

Average dwell duration over the full 5000 msec of each trial was used as the measures of sustained gaze bias in the present study. Difference scores were calculated for angry (threat) compared to neutral face in terms of average dwell duration for each face type per trial. To characterize types of biases based on previous research (Briggs-Gowan et al., 2015), dwell scores were first standardized, and participants with scores that were either 2.5 SD below or above the mean were removed ($n = 2$). Based on percentile ranking of score, participants were divided as follows (top 33.3% = approach threat, middle 33.3% = no bias, bottom 33.3% = bias away from threat). As expected and consistent with previous research (Briggs-Gowan et al., 2015), individuals in the approach threat group had higher than average ($M = .27$, range = .13 to .55), those in the avoid threat had lower than average scores ($M = -.11$, range = $-.35$ to $-.01$), and those in the no bias group were in the average range ($M = .05$, range = 0 to .10).

2.3.2 Modified PTSD Symptom Scale—(mPSS, (Coffey, Dansky, Falsetti, Saladin, & Brady, 1998) is a measure of current (past two weeks) PTSD symptoms. The mPSS is based on the DSM-IV-TR (American Psychiatric Association & American Psychiatric Association, 2000) diagnostic structure (hyperarousal, avoidance/numbness, intrusion) but in line with the DSM-5 (American Psychiatric Association, DSM-5 Task Force, & American Psychiatric Association Publishing, 2017) and evidence delineating avoidance and numbness as distinct factors (Friedman, 2013) we split the avoidance/numbness subscale into two separate

subscales. Thus, we created one total score ($\alpha = .91$) and four subscale scores. The first was hyperarousal (5 items; $\alpha = .79$) with items such as, “Have you been having intense physical reactions (e.g., sweaty, heart palpitations) when reminded of the event?” The second was avoidance (2 items; $\alpha = .72$), with items such as, “Have you persistently been making efforts to avoid thoughts or feelings associated with the event?” The third was anhedonia/numbness (3 items; $\alpha = .77$) with items such as, “Have you felt detached or cut off from others around you since the event?” The final one was intrusions (5 items; $\alpha = .83$), with items such as, “Have you had the experience of suddenly reliving the event(s), flashbacks of it, acting or feeling as it were re-occurring?” For descriptive purposes (see Table 1), we also determined rates of probable PTSD diagnosis within our sample; diagnosis was determined based on whether participants endorsed at least 1 re-experiencing symptom, 3 avoidance and/or numbing symptoms, 2 hyperarousal symptoms for at least one month.

2.3.3 Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988)—was used to assess trait mood state. Participants were asked to rate on a 5-point Likert scale their general experiences with 20 emotional adjectives, 10 describing negative emotional states (e.g., distressed, irritable; $\alpha = .88$) and 10 describing positive emotional states (e.g., excited, proud; $\alpha = .89$). Only negative affect was used for the present study.

2.3.4 Traumatic Events Inventory—(TEI; Gillespie et al., 2009) is a 14-item measure of lifetime history of traumatic events and details frequency and type of trauma(s) experienced; consistent with prior research (Gillespie et al., 2009), total level of trauma exposure was measured by a sum score reflecting the total number of different types of trauma witnessed or experienced. For this study, the sum score of the TEI was used as a covariate in all analyses.

2.4 Data Analytic Plan

We used indirect effects analyses to test our hypotheses regarding attention biases' effects on PTSD symptom clusters through negative affectivity using PROCESS in SPSS (IBM SPSS Version 25). Examining indirect effects allow researchers to test hypotheses about how one variable (X ; attention bias type) transmits its effect on an outcome variable (Y ; PTSD symptom cluster) through an intervening variable (M ; trait affect; Hayes, 2018). In the case of a multi-categorical predictor, the direct and indirect effects of attention bias type (X) quantify the magnitude of separation between the group means (Y) resulting from the effect of trait affect (M). The effect of attention bias type is represented by $g - 1$ regression coefficients, where g is the number of categories or groups (no bias, avoid threat, approach threat). As depicted in Figure 1, rather than the traditional single “ a ” path from X to M , the $g - 1$ coefficients represent one part of the effect of X on M . To quantify these effects, we used effect coding to represent two key contrasts: no bias group vs. avoid threat group (D_1), and no bias group vs. approach threat group (D_2). Given that the no bias group is the reference group, a_1 reflects the mean difference in trait affect for those in the no bias group (M_1) and those in the avoid threat group (M_2), whereas a_2 reflects the mean difference in trait affect for those in the no bias group (M_1) and those in the approach threat group (M_3).

Consistent with traditional testing of indirect effects, b represents the effect of trait affect (M) on PTSD symptoms (Y) controlling for attention bias type (X). The indirect effects, calculated by multiplying the a path coefficients described above with the b path coefficient, each quantify part of the difference in PTSD (Y) resulting from the effect of attention bias type on PTSD through attention biases' effects on trait affect. Continuing for the example above, a_1b quantifies the difference in PTSD between the no bias group and the avoid threat group resulting from the effect of being in the no bias group (vs. the attention away from threat group) on trait affect which, in turn, affects PTSD. Further, a_2b quantifies the difference in PTSD between the no bias group and the approach group resulting from the effect of being in the no bias group (vs. the attention toward threat group) on trait affect which, in turn, affects PTSD. Collectively, a_1b and a_2b quantify the indirect effect of trait affect. As per Hayes (2018) recommendation, the effect of attention bias on PTSD symptom clusters is considered significant if at least one of the indirect effects reaches statistical significance (i.e., 0 is not in the bootstrapped confidence interval).

To test our main and exploratory hypotheses, we ran separate models with attention bias type (attention away from threat, no bias, attention toward threat) as the predictor and PTSD as the outcome (total score, hyperarousal, avoidance, anhedonia/numbness, and intrusions), resulting in a total of five analyses. In each model, we included age and exposure to trauma (total score) as covariates.

3. Results

Indirect effects models with negative affect

As described above, we used the PROCESS macro in SPSS (Hayes 2018) to run a series of models that tested the association between attention bias patterns and PTSD symptoms overall and across the four DSM-5 (APA, 2013) clusters (hyperarousal, avoidance, anhedonia/numbness, and intrusions) and the indirect effect through negative affect in those associations.

We found that the association between attention toward threat and PTSD symptoms was indirectly influenced by negative affect. As reported in Table 2, the indirect effect of D_1 (attention away from threat vs. no bias) was not significant $a_1b = -0.80$, 95%CI [-2.42, 0.85], but the indirect effect of D_2 (attention toward threat vs. no bias) was significant, $a_2b = 2.68$, 95%CI [0.77, 4.98]. Based on the partially standardized coefficient, these results suggest that being in the attention toward threat (vs. no bias) group resulted in an increase in 0.21 standard deviations in PTSD symptoms through the association between attention bias and negative affect.

As reported in Table 3, we found that this pattern remained consistent when we predicted hyperarousal, avoidance, anhedonia/numbness, and intrusive symptoms. Specifically, the indirect effects of D_2 (attention toward threat vs. no bias) were significant and in the same direction across all four symptom clusters. The magnitude of the indirect effect was largest for hyperarousal symptoms ($a_2b_{ps} = .21$) and smallest for avoidance symptoms ($a_2b_{ps} = .10$).

Discussion

This study was the first to use eye-tracking methodology to better understand how affective processes play a role in the association between attention biases and PTSD symptoms. Consistent with our main hypothesis, we found that attention toward threat (compared to attention away from threat and unbiased attention) was associated with higher levels of PTSD symptoms and this association was in part due to the presence of negative affect. This effect of negative affect was consistent across all four PTSD symptom clusters: hyperarousal, avoidance, anhedonia/numbness, and intrusions, showing that across the heterogeneous symptoms of PTSD, negative affect plays an important role in understanding the relationship between threat-related attention bias and PTSD and may be a useful target and/or mechanism of change in treatment.

These results suggest that negative affect may be one important construct through which attention bias toward threat could impact PTSD symptom severity. It is possible that maintaining attention toward threatening stimuli results in greater input of negative cues that are conducive to experiencing negative affect (Böhnke, Lutz, & Delgadillo, 2014). Neurocognitively, this may manifest as deterioration of the salience network, anchored in the dorsal anterior cingulate cortex and the anterior insula, which has implications for individuals' capacity to effectively organize responses to threatening stimuli (Menon, 2015). This is especially consistent for hyperarousal symptoms, which may be characterized as experiencing the physiological correlates of negative affect (Marshall-Berenz, Morrison, Schumacher, & Coffey, 2011). In the case of intrusive symptoms, it is possible that the state of negative affect increases the salience of negative memories through the process of mood-congruent memory (Drace, Efendi, & Mari, 2015). The more individuals experience negative emotions, the more likely they may be to cue negatively-valenced traumatic memories (Drace, 2013; Gupta & Khosla, 2006). Negative affect may also stunt individuals' capacity to experience positive emotions, thus resulting in the anhedonic experience of numbness (Craske, Meuret, Ritz, Treanor, & Dour, 2016). The increase in negative affect may also promote more avoidance behaviors related to trauma-relevant emotions or thoughts, which further maintains PTSD symptoms and feeds into greater negative affect in a vicious loop. Taken together, the overarching association between negative affect and PTSD may play unique and potentially additive roles in the contexts of distinct PTSD symptom clusters.

Our finding that the indirect effects were present for individuals with attention toward threat (but not away from threat) is consistent with recent reviews of the literature showing limited or no evidence for attentional avoidance (Lazarov et al., 2019). One possible explanation is that avoidance of threat at the attentional level is better conceptualized as a risk factor for PTSD than as an etiological factor. Longitudinal work has documented an association between attentional avoidance and later PTSD symptoms in military contexts (Beevers, Lee, Wells, Ellis, & Telch, 2011; Wald et al., 2011). This association has been interpreted as reflecting a tendency for threat avoidance to impede successful processing of trauma and therefore leading to more PTSD symptoms. Another possibility is that threat avoidance specifically increases risk and indirectly plays an etiological role in PTSD through impaired regulatory mechanisms. For example, attending away from threatening and other emotional

stimuli may impair aspects of emotion regulation (e.g., emotional clarity, emotional acceptance) in ways that are relevant to PTSD (Weiss et al., 2012). The more that automatic threat avoidance hinders a person's ability to identify, accept, and process emotions, the more likely that person may be to experience PTSD symptoms such as avoidance or numbness (O'Bryan, McLeish, Kraemer, & Fleming, 2015). Future research is needed to better understand the potential role of threat avoidance in the development and maintenance of avoidance symptoms.

In considering the impact from a treatment perspective, these results suggest that there may be two points to interrupt the downstream effects of the attention to threat: at the attentional level and the negative affect level. Several randomized clinical control trials have found evidence for the utility of attentional control training, which involves training individuals to balance attention allocation between threat and neutral stimuli (Badura-Brack et al., 2015; Lazarov et al., 2018). First-line pharmacological interventions for PTSD such as serotonin reuptake inhibitors (SSRIs) have been found to reduce neural processing of nonconscious (Harmer, Mackay, Reid, Cowen, & Goodwin, 2006) and conscious threat (Murphy, Norbury, O'Sullivan, Cowen, & Harmer, 2009). Such attentional and pharmacological interventions may ameliorate PTSD symptoms by interrupting the initial maladaptive process of automatically over-engaging with threatening stimuli, thus precluding the initiation of negative affect. Alternatively, interventions may focus on increasing affect regulation capabilities (Berking & Whitley, 2014). For example, interventions aiming to increase skills to reduce negative affect (e.g., distress tolerance skills) may have a downstream effect on the amelioration of hyperarousal symptoms. There is evidence that skills-based interventions, such as Skills Training in Affective and Interpersonal Regulation, can be helpful in improving affective regulation abilities in individuals with PTSD characterized by chronic trauma (Cloitre et al., 2010). Another strategy may be to change one's relationship with their emotions to be characterized by acceptance rather than avoidance (Longmore & Worrell, 2007). Consistent with an acceptance and commitment therapy approach, individuals may be encouraged to "defuse" from their emotions in ways that reduce the impact of negative affect on subsequent PTSD symptoms (Bean, Ong, Lee, & Twohig, 2017). However, it is unclear which approach may be more effective at interrupting the process of over-engaging with threat.

There may be various benefits and disadvantages to targeting change at the levels of attentional processes and negative affect. Targeting attentional processes directly through attentional control training or pharmacologically through serotonergic pathways (Berger et al., 2019) has the potential benefit of being preventative, in that it may reduce the onset of negative affect, and thus reduce the need for the use of more complex, cognitively-costly regulatory skills. Biased attention toward threat, however, is only one trigger of negative affect, and thus a sole focus on reducing the bias would not have an impact on other negative affect-inducing stressors such as interpersonal conflicts or daily stressors. Particularly because negative affect also plays a role in various risky behaviors ranging from nonsuicidal self-injury (Bresin & Gordon, 2013) to alcohol use (Bresin, Mekawi, & Verona, 2018), developing skills to reduce (or accept) negative affect may have a larger impact on overall wellbeing compared to strategies focused on attention to threat. Nevertheless, a focus on both reducing the experience of negative affect through attentional control training *and*

intervening when negative affect is experienced through emotion regulation skills may be useful. Given evidence of SSRIs' utility in also targeting disorders that commonly co-occur with PTSD and are associated with negative affect (e.g., depression), it is possible that the benefits of these interventions may be strengthened through pharmacological treatment (Hidalgo & Davidson, 2000). Intervention research studies comparing and testing potentially additive effects of attentional, psychological, and pharmacological interventions are needed to identify efficient and effective strategies that can help to advance or improve PTSD treatment success.

This study has several limitations. First, due to the cross-sectional design, we were unable to provide evidence for causal and temporal processes in our model. Although a causal influence of attention bias on negative affect has been documented in the literature (Mathews & MacLeod, 2002), it is unclear whether that relationship may be interdependent (Van Bockstaele et al., 2014). For example, experiencing frequent negative affect may also make it difficult to disengage from threatening material (Smith et al., 2006). In addition, when considering the negative affect-PTSD component of our model, it is possible that experiencing more PTSD symptoms may increase the experience of negative affect (Dornbach-Bender et al., 2019). However, evidence that negative affect develops at an early age and is associated with risk for the development of psychopathology (Shackman et al., 2016), supports our model. Nonetheless, these results should be considered preliminary and the nature of these potentially mutually reinforcing relationships warrants further examination through longitudinal designs. The use of a self-report measure of PTSD symptoms is also a limitation; semi-structured assessments are the gold standard for diagnosing PTSD and identifying level of symptoms. However, prior research in our laboratory has shown good reliability between mPSS and clinical diagnoses of PTSD using the Clinician Administered PTSD scale (van Rooij et al., 2016). Additionally, our relatively small sample size and small effect sizes highlight the need for studies with larger samples to replicate these analyses. Particularly because eye tracking studies have generally had small samples, future work might benefit from prioritizing the recruitment of larger samples or working collaboratively with other researchers to pool data across sites. Finally, the specificity of our sample also may limit generalizability of the results to other populations with different demographic intersections (e.g., White men). There is some limited evidence that gender may play a role in attention biases (Sass et al., 2010) and thus understanding how these patterns differ across gender is critical for future studies. The limitation on generalizability is counterbalanced by the fact that this study focused on a high risk, trauma-exposed population experiencing marginalization on various levels, including race, gender, and socioeconomic status (Davis, Ressler, Schwartz, Stephens, & Bradley, 2008). Not only is this population understudied and underserved in clinical science research (Ford et al., 2013), but there is also evidence that its members are more likely to drop out of treatment studies (Lester, Artz, Resick, & Young-Xu, 2010) and less likely to access PTSD care (Spoont et al., 2015). Thus, more research on basic psychological processes is needed to develop culturally- and scientifically-informed interventions for this population (Graves et al., 2011).

In conclusion, our study is the first to provide evidence for the role of negative affect in the association between threat-related attention bias and PTSD symptoms using eye-tracking

methodology. This study contributes to our understanding of the etiological processes of threat-related attention biases and identifies several avenues for innovative research questions that will enhance our understanding of how attentional processes play a role in PTSD. This work highlights the utility of examining potential sequelae of dysregulated attention and informing interventions designed to interrupt pathological processes.

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Highlights

- Difficulty looking away from threat is associated with more negative affect
- More negative affect is associated with more posttraumatic stress
- Negative affect partly explains attention to threat/posttraumatic stress relation

Figure 1.
Conceptual model of analyses

Table 1.

Demographics for full sample and by attention bias type

		Total Sample (<i>n</i> = 92)	Attention Away from Threat (<i>n</i> = 30)	No Bias (<i>n</i> = 32)	Attention Toward Threat (<i>n</i> = 32)
% Meet Criteria for PTSD		48.1	40	42.9	61.1
Age	Range	18–64	19–64	18–60	20–54
	Mean (<i>SD</i>)	40.79 (11.79)	42.51 (11.49)	40.63 (12.02)	29.28 (11.95)
Traumatic Events	Range	0–11	0–10	0–9	1–11
	Mean (<i>SD</i>)	3.99 (2.48)	3.98 (2.46)	3.66 (2.16)	4.36 (2.81)
PTSD Total	Range	0–45	0–45	0–36	0–45
	Mean (<i>SD</i>)	18.34 (12.58)	16.02 (12.21)	15.57 (11.10)	23.28 (13.13)
Avoidance	Range	0–6	0–6	0–6	0–6
	Mean (<i>SD</i>)	2.86 (2.20)	2.31 (2.09)	2.51 (2.27)	3.75 (2.25)
Numbness	Range	0–9	0–7	0–8	0–9
	Mean (<i>SD</i>)	2.71 (2.75)	2.00 (2.46)	2.14 (2.53)	4.0 (3.27)
Hyperarousal	Range	0–15	0–15	0–12	0–15
	Mean (<i>SD</i>)	6.83 (4.52)	5.91 (4.93)	6.54 (3.91)	8.00 (4.52)
Intrusions	Range	0–15	0–14	0–12	0–15
	Mean (<i>SD</i>)	4.56 (4.22)	4.40 (4.14)	3.37 (3.61)	5.86 (4.57)
Negative Affect	Range	10–43	10–31	10–36	11–43
	Mean (<i>SD</i>)	22.22 (8.05)	20.97 (6.52)	19.72 (7.40)	25.91 (8.81)

Note. The traumatic events values reflect an aggregate number of traumas across several domains, including: natural disasters, experiencing/ witnessing severe violence and/or sexual abuse, being confronted with the murder of a family member, or experiencing/witness a serious accident.

Table 2

Model Summary Information for the Indirect Effects Through Negative Affect

		Y (PTSD Total)						M (Negative Affect)						Y (Total PTSD)				Relative Indirect Effects			
		Coeff	SE	95% CI	p			Coeff	SE	95% CI	p			Coeff	SE	95% CI	p			Effect	95%CI
D_1	c_1	-2.06	1.73	[-5.49, 1.37]	0.24	a_1	-1.01	1.11	[-3.22, 1.20]	0.37	c'_1	-1.26	1.5	[-4.24, 1.71]	0.40	<i>Unstandardized</i>					
D_2	c_2	4.53	1.71	[1.15, 7.94]	0.01	a_2	3.38	1.10	[1.19, 5.57]	<.01	c'_2	1.86	1.55	[-1.22, 4.94]	0.23	a_1b	-0.80	[-2.42, .85]			
Negative Affect		/	/	/	/		/	/	/	/	b	0.79	0.14	[.51, 1.07]	<.001	a_2b	2.68	[.77, 4.98]			
Constant	i_Y	4.59	5.17	[-5.70, 14.87]	0.38	i_M	19.18	3.34	[12.54, 25.82]	<.001	i_Y	-10.61	5.23	[-21.01, -.20]	0.05	<i>Partially Standardized</i>					
Age		0.15	0.11	[-.07, .36]	0.18		-0.02	0.07	[-.15, .12]	0.80		0.16	0.09	[-.03, .34]	0.09	a_1b_{ps}	-0.06	[-.19, .06]			
Trauma		0.21	0.07	[.08, .35]	<.01		0.1	0.04	[.01, .19]	0.02		0.13	0.06	[.02, .25]	0.03	a_2b_{ps}	0.21	[.06, .38]			

Note. D_1 = (No bias vs. attention away from threat); D_2 = (No bias vs. attention toward threat); Age and Trauma included in model as covariates

Table 3

Model Summary Information for the Indirect Effects Through Negative Affect

Hyperarousal Symptoms																			
		<i>Y</i> (Hyperarousal)						<i>M</i> (Negative Affect)						<i>Y</i> (Hyperarousal)				Relative Indirect Effects	
		Coeff	SE	95% CI	<i>p</i>			Coeff	SE	95% CI	<i>p</i>			Coeff	SE	95% CI	<i>p</i>	Effect	95% CI
<i>D</i> ₁	<i>c</i> ₁	−0.88	0.63	[−2.13, .38]	0.12	<i>a</i> ₁	−1.00	1.11	[−3.22, 1.20]	0.37	<i>c</i> ₁	−0.62	0.6	[−1.72, .51]	0.22	<i>Unstandardized</i>			
<i>D</i> ₂	<i>c</i> ₂	1.2	0.62	[−.09, 2.39]	0.07	<i>a</i> ₂	3.38	1.10	[1.19, 5.57]	<.01	<i>c</i> ₂	0.24	0.6	[−.91, 1.39]	0.65	<i>a</i> ₁ <i>b</i>	−0.27	[−.83, .30]	
Negative Affect		/	/	/	/		/	/	/	/	<i>b</i>	0.28	0.	[.17, .38]	<.01	<i>a</i> ₂ <i>b</i>	0.92	[.28, 1.70]	
Constant	<i>i</i> _{<i>Y</i>}	4.32	1.89	[−.82, 6.70]	0.03	<i>i</i> _{<i>M</i>}	19.18	3.34	[12.54, 25.82]	<.01	<i>i</i> _{<i>Y</i>}	−2.26	2	[−6.15, 1.63]	0.25	<i>Partially Standardized</i>			
Age		0.03	0.04	[−.04, .11]	0.51		−0.02	0.07	[−.15, .12]	0.80		0.04	0	[−.03, .11]	0.31	<i>a</i> ₁ <i>b</i> _{<i>ps</i>}	−0.06	[−.19, .07]	
Trauma		0.07	0.03	[.02, .11]	0.01		0.10	0.04	[.01, .19]	0.02		0.04	0	[−.01, .08]	0.54	<i>a</i> ₂ <i>b</i> _{<i>ps</i>}	0.21	[.06, .37]	
Avoidance Symptoms																			
		<i>Y</i> (Avoidance)						<i>M</i> (Negative Affect)						<i>Y</i> (Avoidance)				Relative Indirect Effects	
		Coeff	SE	95% CI	<i>p</i>			Coeff	SE	95% CI	<i>p</i>			Coeff	SE	95% CI	<i>p</i>	Effect	95% CI
<i>D</i> ₁	<i>c</i> ₁	−0.34	0.17	[−.67, −.01]	0.05	<i>a</i> ₁	−1.00	1.11	[−3.22, 1.20]	0.37	<i>c</i> ₁	−0.31	0.2	[−.62, .02]	0.07	<i>Unstandardized</i>			
<i>D</i> ₂	<i>c</i> ₂	0.47	0.17	[.14, .80]	<.01	<i>a</i> ₂	3.38	1.10	[1.19, 5.57]	<.01	<i>c</i> ₂	0.35	0.2	[.02, .69]	0.04	<i>a</i> ₁ <i>b</i>	−0.04	[−.13, .04]	
Negative Affect		/	/	/	/		/	/	/	/	<i>b</i>	0.03	0	[.004, .07]	0.03	<i>a</i> ₂ <i>b</i>	0.12	[.01, .29]	
Constant	<i>i</i> _{<i>Y</i>}	0.79	0.50	[−.211, 1.79]	0.12	<i>i</i> _{<i>M</i>}	19.18	3.34	[12.54, 25.82]	<.01	<i>i</i> _{<i>Y</i>}	0.12	0.6	[−1.02, 1.26]	0.84	<i>Partially Standardized</i>			
Age		0.01	0.01	[−.01, .03]	0.51		−0.02	0.07	[−.15, .12]	0.80		0.01	0	[−.012, .03]	0.47	<i>a</i> ₁ <i>b</i> _{<i>ps</i>}	−0.03	[−.11, .04]	
Trauma		0.01	0.01	[−.01, .02]	0.14		0.10	0.04	[.01, .19]	0.02		0.01	0	[−.01, .02]	0.34	<i>a</i> ₂ <i>b</i> _{<i>ps</i>}	0.10	[.01, .25]	
Anhedonia/Numbness Symptoms																			
		<i>Y</i> (Numbness)						<i>M</i> (Negative Affect)						<i>Y</i> (Numbness)				Relative Indirect Effects	
		Coeff	SE	95% CI	<i>p</i>			Coeff	SE	95% CI	<i>p</i>			Coeff	SE	95% CI	<i>p</i>	Effect	95% CI
<i>D</i> ₁	<i>c</i> ₁	−0.17	0.14	[−.44, .10]	0.22	<i>a</i> ₁	−1.00	1.11	[−3.22, 1.20]	0.37	<i>c</i> ₁	−0.11	0.1	[−.35, .13]	0.37	<i>Unstandardized</i>			
<i>D</i> ₂	<i>c</i> ₂	0.37	0.14	[.10, .64]	<.01	<i>a</i> ₂	3.38	1.10	[1.19, 5.57]	<.01	<i>c</i> ₁	0.18	0.1	[−.07, .43]	0.16	<i>a</i> ₁ <i>b</i>	−0.06	[−.18, .06]	

Negative Affect	/	/	/	/	/	/	/	/	/	b	0.06	0	[.03, .08]	<.01	a_2b	0.19	[.05, .38]	
Constant	i_Y	0.11	0.41	[-.71, .92]	0.79	i_M	19.18	3.34	[12.54, 25.82]	<.01	i_Y	-0.98	0.4	[-1.83, -.13]	0.03	<i>Partially Standardized</i>		
Age		0.01	0.01	[-.01, .02]	0.42		-0.02	0.07	[-.15, .12]	0.80		0.01	0	[-.01, .03]	0.30	a_1b_{ps}	-0.06	[-.18, .06]
Trauma		0.02	0.01	[.004, .03]	<.01		0.10	0.04	[.01, .19]	0.02		0.01	0.00	[-.00, .02]	0.06	a_2b_{ps}	0.19	[.05, .38]
Intrusion Symptoms																		
		Y (Intrusion)					M (Negative Affect)					Y (Intrusion)				Relative Indirect Effects		
		Coeff	SE	95% CI	p		Coeff	SE	95% CI	p		Coeff	SE	95% CI	p	Effect	95% CI	
D_1	c_1	-0.13	0.59	[-1.32, 1.05]	0.82	a_1	-1.00	1.11	[-3.22, 1.20]	0.37	c'_1	0.08	0.6	[-1.02, 1.17]	0.88	<i>Unstandardized</i>		
D_2	c_2	1.14	0.59	[-.03, 2.31]	0.06	a_2	3.38	1.10	[1.19, 5.57]	<.01	c'_2	0.43	0.6	[-.71, 1.56]	0.45	a_1b	-0.21	[-.68, .23]
Negative Affect	/	/	/	/	/	/	/	/	/	/	b	0.21	0.1	[.11, .31]	<.01	a_2b	0.71	[.18, 1.41]
Constant	i_Y	0.05	1.78	[-3.48, 3.58]	0.97	i_M	19.18	3.34	[12.54, 25.82]	<.01	i_Y	-3.98	1.9	[-7.81, -.15]	0.04	<i>Partially Standardized</i>		
Age		0.06	0.04	[-.01, .13]	0.11		-0.02	0.07	[-.15, .12]	0.80		0.06	0	[-.01, .13]	0.07	a_1b_{ps}	-0.05	[-.16, .05]
Trauma		0.06	0.03	[.01, .10]	0.02		0.10	0.04	[.01, .19]	0.02		0.03	0	[-.01, .08]	0.12	a_2b_{ps}	0.17	[.05, .32]

Note. D_1 = (No bias vs. attention away from threat); D_2 = (No bias vs. attention toward threat); Age and Trauma included in model as covariates