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Research Paper

The impact of aversive context on early threat detection in trauma exposed individuals and associations with post-traumatic stress symptoms

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ABSTRACT

Introduction: Prolonged attentional bias to threat (AB) is associated with posttraumatic stress symptoms (PTSS). However, it is unclear whether this relationship extends to early threat detection (elicited by masked stimuli) and/or varies if AB is measured during an aversive context.
Methods: Two trauma-exposed samples of either intervention-seekers ($N = 50$) or community members ($N = 98$) completed a masked dot-probe task to measure early AB to angry faces in safe vs. aversive contexts (i.e., during threat of aversive noises).
Results: Linear mixed effects models showed that an aversive context increased the orienting responses in both samples; however, PTSS did not moderate these effects in either sample.
Limitations: Sample size and heterogeneity of trauma-type may have impacted effect of PTSS on AB.
Conclusion: These results highlight the importance of assessing AB in varying contexts and examining generalizability across populations. Given prior research, the results also suggest that increased AB in PTSS may only be present for later attentional processes rather than early threat detection, at least with behavioral methods.

1. Introduction

Approximately 90% of U.S. adults have experienced a traumatic event in their lifetime, yet only about 10% of these individuals will meet full criteria for posttraumatic stress disorder (PTSD; Kilpatrick et al. 2013). Trauma exposure is therefore a necessary but insufficient causal mechanism for posttraumatic stress symptoms (PTSS), suggesting that it is important to identify other etiological factors. Information processing biases are one set of etiological factors that might contribute to the onset and maintenance of PTSS (Buckley et al., 2000).

One specific information processing bias that may be particularly relevant for PTSS is attentional bias (AB) to threat. AB to threat is a set of processes reflecting the tendency to disproportionately focus on negative or threatening stimuli (Buckley et al., 2000). One meta-analysis examined 22 studies in 502 individuals and found a moderate and stable effect size of .36 for the relationship between PTSD and AB (Bar-Haim et al., 2007). Whereas this meta-analysis only examined categorically defined PTSD (i.e., diagnosis), when PTSD was defined dimensionally, studies have continued to find associations between PTSD symptom severity and AB (Bar-Haim et al., 2010; Cisler et al., 2011) .

It is unclear which component of AB is most atypical in PTSS. This gap in knowledge could be from inconsistencies in the measurement of AB as well as which metrics are elicited from the task. A popular behavioural measure of AB is the dot-probe task (MacLeod et al., 1986), a reaction time (RT) measure that assesses participant's attention to threatening versus neutral stimuli. Although researchers use different versions/scoring of the task, traditionally, the dot-probe yields three variables: total AB (i.e., average attentional bias), disengagement (i.e., difficulty disengaging from threatening stimuli), and orientation (i.e., heightened orientation towards threatening stimuli). Studies of different AB processes in PTSD have been inconsistent showing both difficulty disengaging from threat (Pineles et al., 2009) and avoidance of threat (Bar-Haim et al., 2010).

Importantly, Bar-Haim et al. (2007) argued that automatic/rapid detection of threat is a key symptom of anxiety. However, most studies

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of AB in PTSD (and anxiety generally) use longer presentations of stimuli (> 500 ms) and thus confound automatic threat detection with a later occuring threat processing . It is therefore unclear whether the AB deficits in PTSD represent an early or later bias in attention to threat. One way to isolate automatic, early AB is to use briefly presented aversive stimuli followed immediately by positive stimuli, essentially "masking" the threatening stimuli (Lavie, 1995). Masked dot-probe tasks have been shown to trigger amygdala activity in PTSD (Whalen et al., 1998), and a meta-analysis of 28 dot-probe studies found that attention is still biased to threat even if the stimuli are presented pre-consciously (Hedger et al., 2016). Few studies have examined AB to masked stimuli in individuals with PTSS/PTSD, but one small study showed that individuals with PTSD exhibit increased amygdala reactivity to masked faces (Rauch et al., 2000). To our knowledge, no study has examined whether PTSS/PTSD is associated with behavioral differences to masked threats.

It is also possible that individual differences in AB are related to the environmental context of the task. Studies that induce negative moods have altered cognitive processes such as memory for affective words (Cavanagh et al., 2011). Research into the dot-probe task under differing contexts is limited, but suggests that attention can be modulated by the environmental context in which it is assessed (Shechner et al., 2012). Thus, certain negative contexts may exacerbate AB in individuals with PTSS, but it is unclear whether this extends to masked stimuli (and thus, earlier AB).

Lastly, psychology is facing a replication and generalizability crisis. Generalizability-that is, whether research results from homogenous study samples will apply to diverse clinical groups (Kukull and Ganguli, 2012)-is concerning given the heterogeneity and mixed clinical presentations of most psychopathology. To address this, the present study tested the generalizability of findings by examining whether the results from a sample of trauma-exposed individuals prior to engaging in a resiliency intervention are also found in a larger community sample of trauma-exposed individuals.

In sum, the first aim of this study was to test whether AB to masked threats differed when assessed under a "safe" versus "aversive" context. We hypothesized that AB would be higher in aversive than the safe contexts. The second aim of the study was to establish whether (a) the literature showing an association between PTSS and AB generalizes to early-threat detection with a masked dot-probe, and (b) the associations between PTSS and AB are moderated by context. For aim 2, we hypothesized that individuals with greater PTSS will have greater attentional bias than those with less PTSS. For both aims, generalizability was addressed by running analyses in a trauma-exposed treatment-seeking sample (pre-treatment), and then repeating analyses in a larger, trauma-exposed, community sample.

2. Materials and methods

2.1. Study 1

2.1.1. Participants

This study used participants ($N = 50$) from a randomized controlled trial (K23MH103394; NCT02279290) examining a resiliency intervention for survivors of childhood interpersonal trauma. Participants were recruited from clinics and community organizations, and were included if they were over age 18, fluent in English, had a history of childhood interpersonal trauma (e.g., sexual assault, physical assault, witnessing assault before age 18), as well as at least mild current distress as assessed by the Depression Anxiety Stress Scale-21 (Lovibond and Lovibond, 1995). Participants were excluded if they experienced a DSM-5 (American Psychiatric Association, 2013) defined traumatic event within one month prior to recruitment, had colorblindness, auditory impairment, concurrent psychotherapy initiated within 3 months of randomization (as this was a prevention study), significant cognitive impairment, serious medical illness or instability for which hospitalization within the next year would be likely, significant suicidal ideation, or current legal actions related to their trauma. Participants ranged in age from 20–74, and 44% met criteria for current PTSD at the time of assessment (see Table 1).

2.1.2. Questionnaires and interviews

Study 1 participants completed the PTSD Checklist for DSM-5, a 20-item self-report measure that yields a total PTSS severity score (Blevins et al., 2015).

Participants also completed the Work and Social Adjustment Scale (WSAS; Zahra et al. 2014), a five-item self-report scale measuring functional impairment. The WSAS was used as a covariate for models examining associations between PTSS and AB in Aim 2 as a proxy for physical and psychiatric comorbidities.

2.2. Study 2

2.2.1. Participants

This study used participants drawn from a larger family study (Correa et al., 2019) that recruited community members aged 18-30 with a wide range of psychopathologies. Consistent with the Research Domain Criteria, recruitment screening was agnostic to DSM diagnostic categories; however, participants with severe internalizing psychopathology were oversampled to ensure that the sample was clinically relevant (see Correa et al. 2019 for full inclusion criteria).

For this study, we selected the 97 trauma-exposed participants exhibiting at least one current DSM-5 symptom of PTSD. Participants were nested within 82 families, including 16 sibling pairs.

2.2.2. Questionnaires and interviews

Participants received the Structured Clinical Interview for DSM-5 (First et al., 2015), and after a participant met Criteria A (i.e., experienced a trauma), all other symptoms were assessed on a 1-3 scale, creating dimensional PTSD severity scores by summing the 20 symptoms assessed in the PTSD module.

Participants also received the World Health Organization Disability Assessment Schedule 2.0 (WHODAS 2.0), a 36-item interview designed to assess health and disability globally (Üstün et al., 2010). The primary factor, General Disability, was included as a covariate in this study as a proxy for overall psychiatric severity/comorbidity.

Table 1
Participant demographics and characteristics.

Characteristic	Study 1 ($N = 50$)	Study 2 ($N = 97$)
Age-Mean (SD)	43.64 (15.58)	22.57 (3.04)
Race/Ethnicity-*N* (%)		
White/Caucasian	24 (48%)	38 (39.2%)
Black or African American	21 (42%)	28 (29%)
Asian	2 (4%)	5 (5.2%)
Other or Declined to Answer	3 (6%)	8 (8.2%)
Hispanic/Latino	4 (8%)	18 (18.6%)
Gender (% female identifying)	37 (74%)	78 (80%)
Lifetime Diagnoses-*N* (%)		
Post-traumatic Stress Disorder	27 (54%)	31 (32%)
Major Depressive Disorder	35 (70%)	56 (57.7%)
Generalized Anxiety Disorder	9 (18%)	21 (21.6%)
Panic Disorder	8 (16%)	16 (16.5%)
Social Anxiety Disorder	14 (28%)	32 (33%)
Obsessive-Compulsive Disorder	6 (12%)	11 (11.3%)
Specific Phobia	9 (18%)	27 (27.8%)
Substance Use Disorder	47 (94%)	34 (35.1%)
Current Diagnoses-*N* (%)		
Post-traumatic Stress Disorder (PTSD)	22 (44%)	6 (6.2%)
PTSD Severity Score-Mean (SD)	26.01 (14.61)	27.20 (6.64)
Major Depressive Disorder	8 (16%)	12 (12.4%)
Generalized Anxiety Disorder	4 (8%)	9 (9.3%)
Panic Disorder	2 (4%)	6 (6.2%)
Social Anxiety Disorder	12 (24%)	21 (21.6%)
Obsessive-Compulsive Disorder	5 (10%)	10 (10.3%)
Specific Phobia	4 (8%)	21 (21.6%)
Substance Use Disorder	26 (52%)	10 (10.3%)

2.3. Dot-probe task

The same dot-probe task was administered in both Study 1 and Study 2, and in Study 1, all measures and tasks were administered prior to any intervention. Each trial in the dot-probe task began with a 1-s, centered fixation cross, followed by two faces (either both neutral; or one threatening/angry face and one neutral face) of the same person presented simultaneously and briefly (33-ms) to the left and right of the fixation cross. The threatening/neutral faces then disappeared and were replaced with a mask (100-ms) of two images of the same person making a happy face (see Egloff and Hock, 2003). After the happy face mask, a dot was immediately presented in either the left or right quadrant, and the RT of participant's detection of the dot's location was recorded (see Fig. 1). Happy face masks were selected because if neutral masks were used following the presentation of threatening and neutral face pairing, the subject would perceive a change in the threatening side of the screen but not the neutral (as neutral would be replacing neutral), confounding the experimental conditions. Participants were instructed to press a button corresponding to the side of the screen on which the dot appeared as quickly and accurately as possible.

There were three types of trials: Congruent, Incongruent, and Neutral. In Congruent trials, there was one neutral and one threatening face with the dot replacing the threatening face. In Incongruent trials, there was one neutral and one threatening face with the dot replacing the neutral face. In Neutral trials, there were two neutral faces with the dot replacing one of the neutral faces. The location of the threatening face was counterbalanced. In neutral trials, both faces were of the same person displaying a neutral expression. There were equal numbers of male and female faces and faces with open and closed mouths. Faces were drawn at random from the NimStim databank, which was racially diverse and included individuals who identify as Asian-American, African-American, European-American, and Latino-American actors (see Tottenham et al. 2009). Due to the diversity of this sample, the race/-ethnicity of the participant did not necessarily match the race/ethnicity of the stimulus face. Twenty-four trials of each condition were presented across two blocks, resulting in a total of 72 trials.

As per Aim 1, participants from both samples completed the dot-probe task under 'aversive' and 'safe' contexts in a counterbalanced order. During the aversive context, participants heard random presentations of a woman screaming or a metal garden fork scraping on a chalkboard. During the safe context, no sounds were presented.

As mentioned, the dot-probe task was identical in Study 1 and Study 2, apart from one discrepancy. In Study 2, due to a computer processing error, the number of safe and aversive trials was not equivalent across the two contexts. To ensure an equal number of trials included per context, 19 trials of each context were randomly selected for inclusion in the following analyses, resulting in 114 total trials (a total 79% of trials maintained). The accuracy for dot-probe in the parent sample for Study 2 (i.e., correctly clicking on the side of the screen as the dot) was 97.7% at the trial level. Individual-level accuracy data was unavailable for Study 1, although all incorrect trials were excluded.

2.4. Data analysis

As per standard practice (Price et al., 2015), all incorrect trials (i.e., incorrectly identifying the dot location) were discarded. To account for outliers, RT values outside 2.5 standard deviations for each Trial Type were winsorized. Average RT scores were calculated for the three Trial Types (Incongruent, Congruent and Neutral). As data were skewed after winsorizing, Trial Type averages were also log transformed. Using these

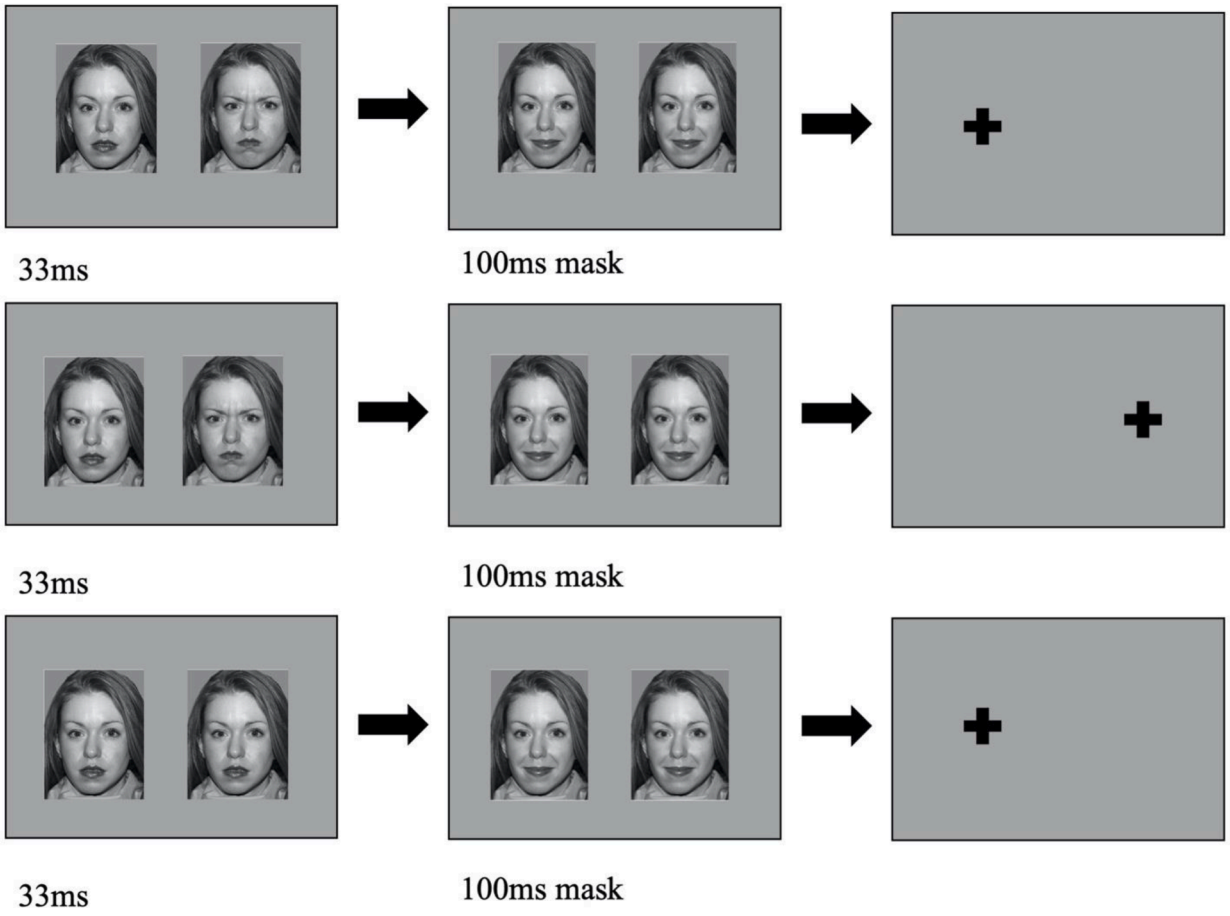

Fig. 1. Dot-probe incongruent, congruent, and neutral trial examples, respectively (pictures from Tottenham et al. 2009).

values, the following AB Metrics were calculated: (1) Attention Bias (Incongruent RT-Congruent RT), reflecting attentional vigilance toward (positive scores) and attentional avoidance away (negative scores) from the emotional face; (2) Disengagement (Incongruent RT - Neutral RT), reflecting disengagement from threat; and (3) Orientation (Neutral RT-Congruent RT), reflecting orientation to threat. Missing data were mean-imputed.

Both aims were addressed with linear mixed effects models to account for the repeated measures design within participants-Context (Safe vs. Aversive) nested within Trial Type (Incongruent, Congruent, and Neutral) or AB metric (total AB, Orientation, and Disengagement), nested within participants. Prior to examining the AB metrics (i.e., difference scores), the omnibus mixed effects model including Context, Trial Type, and their interaction as fixed effect predictors of RT was used to test whether there were differences between any of the trial types (incongruent, congruent, and neutral) and/or contexts. To follow up the omnibus model, three separate mixed effects models examined the effect of Context on each of the three AB Metrics (overall AB, Orientation, Disengagement) obtained from difference scores of Trial Type. Conceptually, these analyses can be understood as an omnibus 2 × 3 ANOVA with pairwise follow-up t-tests; however, given the nested nature of this study design, all analyses were run as mixed effects models.

To test whether PTSD severity moderated the effects tested in Aim 1, mixed effects models examined the interaction of dimensional PTSD and Context to predict each of the three AB Metrics. To further examine generalizability, all analyses were run separately in Study 1 and Study 2. All models included a random effect at the participant level. Study 2 analyses also included a family-level random effect.

Regarding covariates for Aim 2, in Study 1, to increase inclusivity, there were separate models covarying for sex assigned at birth and affirmed gender. Separate variables for sex and gender were not assessed in Study 2, thus models only covaried for reported sex. Additionally, given the prevalence of current and lifetime psychopathology in both samples, models included a global functioning covariate (WSAS or WHODAS) to act as a proxy for these comorbidities. We chose this approach towards covarying for comorbidity/severity because including all categorical diagnoses is inappropriate given the large number of possible variables. Moreover, including a single variable measuring whether participants had any additional diagnosis removes the potential impact of multiple comorbidities, and including total number of diagnoses assumes that each diagnosis is of comparable severity.

3. Results

3.1. Aim 1: is masked AB different under safe versus aversive context?

In Study 1, the results from the omnibus model in Aim 1 predicting RT yielded a significant Context *x* Trial Type interaction ($F(2, 149.97) = 4.37$, $p < .05$), as well as significant main effects of Context ($F(1, 50) = 5.25$, $p < .05$) and Trial Type ($F(2, 72.61) = 5.05$, $p < .01$; see Fig. 2). The pairwise differences between Trial Types, regardless of Context, were all nonsignificant (all ps <.1). Follow up models showed a significant impact of Context on Orientation bias (*ss* (49) = 2.87, $p < .01$) but not overall AB (t(98)=1.35, p=.18) nor Disengagement (t(49)=-1.58, $p = .12$), indicating that there were significantly heightened Orientation biases in the aversive ($b = .025$) compared to safe context.

In Study 2, the Context x Trial Type interaction (F(2, 405.25)=1.10, $p = .33$; see Fig. 2) and main effect of Context (F(1, 74.25)=.41, $p = .53$) in the omnibus model were nonsignificant. The pairwise differences between Trial Types, regardless of Context, were all nonsignificant (all ps <.1). However, there was a marginal main effect of Trial Type (F(2, 405.25)=2.87, $p = .058$). Although the omnibus interaction effect was not significant, to parallel the analyses in Study 1, this interaction was similarly followed up here. These analyses yielded a marginally significant effect of Context on Orientation bias (t(192) =1.98, p=.062), but not overall AB (t(71.37)=0.62, $p = .54$) nor Disengagement (t(84.12)=-0.75, $p = .45$), again indicating a trend of increased Orientation bias in the aversive context ($b = .013$) compared to the safe context. Importantly, the results for Study 2 should be interpreted with caution given the lack of a significant interaction in the omnibus model.

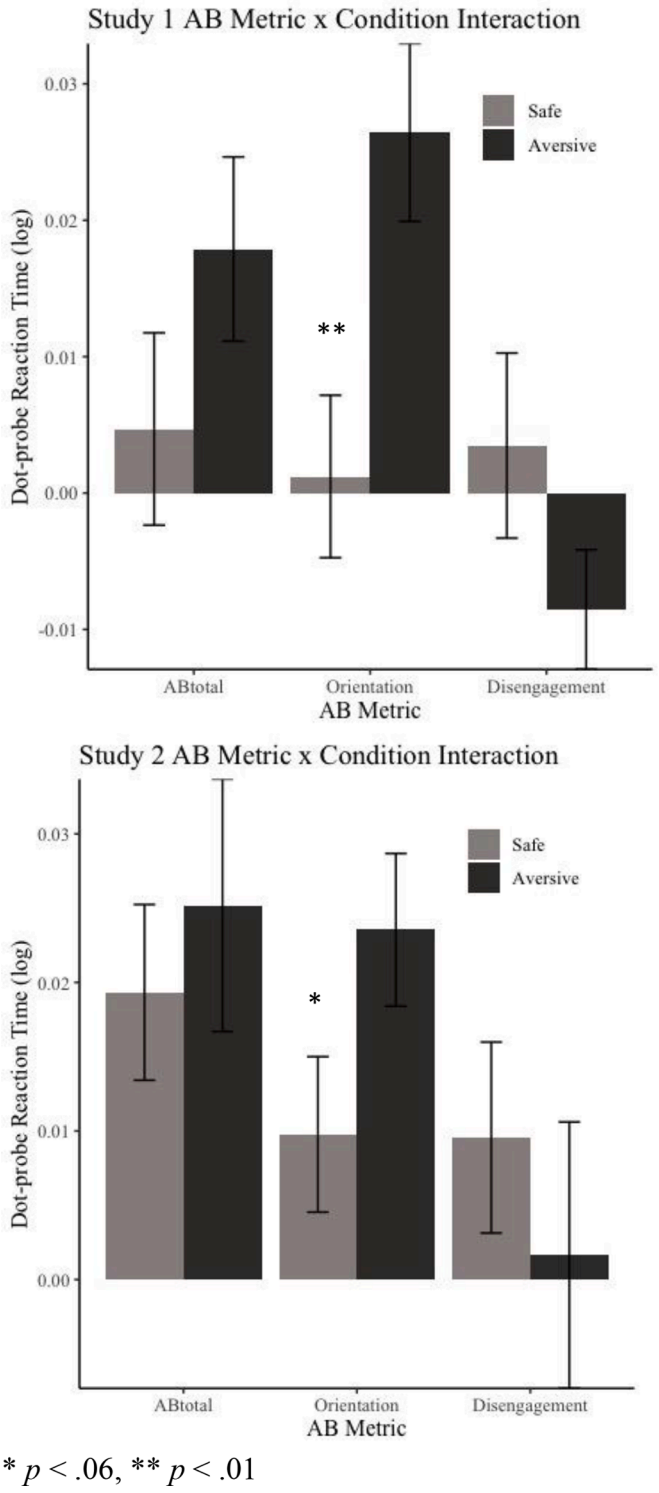

Fig. 2. Effects of safe vs. aversive contexts on attentional bias to masked faces.

3.2. Aim 2: does PTSS moderate the relationship between masked AB and context?

PTSS did not significantly interact with context to predict any of the

three AB Metrics in either Study 1 or Study 2, regardless of whether the models covaried for sex/gender and/or global functioning (all ps > .12). Results for main effects and interactions are presented in Table 2.

4. Discussion

These results show that AB to masked stimuli in trauma-exposed populations may be altered when measured in an aversive context, as the omnibus model testing the moderating effect of Context in Aim 1 was significant in Study 1, but not in Study 2. However, follow up models in both samples revealed that the same type of bias-Orientation-was especially impacted by the aversive context. The tests for Aim 2 did not yield any association between PTSS and masked AB in any of the metrics.

These results emphasize the importance of examining the components of AB as its mechanism is often viewed as having both bottom-up (e.g., threat-detection) and top-down (e.g., attentional control) components (Cisler et al., 2011). It is difficult to disambiguate the different aspects of AB from the overall AB metric (Incongruent-Congruent). Separately examining Orientation and Disengagement allows AB to be examined in its component parts. In Study 1, bias was moderated by the aversive environment resulting in heightened Orientation towards the threatening stimuli (this effect was trending in Study 2). Importantly, the aversive context did not impact participants' abilities to disengage from the threatening image; although, given the brevity in which the threatening image was presented (33ms), participants may not have had the time to fully "engage and then disengage." That is, as the masked dot-probe elicits early threat detection, it follows that effects would be stronger for orientation bias rather than a longer process like disengagement (Cisler et al., 2011). Taken together, this suggests that in an aversive context, trauma-exposed participants were immediately more hypervigilant towards the threatening image, but they reallocated their attention back towards the probe without any concerning difficulty.

To our knowledge, no study has examined AB to masked threatening stimuli under different contexts. However, several studies have examined unmasked context-dependent AB. Using shock anticipation to create an aversive context, one study showed that participants exhibit an avoidance of threatening words (Shechner et al., 2012), and another found that participants had difficulty disengaging from a cognitive task during an aversive context (Choi et al., 2012). Together with the results from Aim 1, these studies suggest that attention can be altered by aversive contexts and perhaps specifically impacting greater early hypervigilance and threat detection.

It remains unclear, however, why the results from Aim 1 did not fully generalize from Study 1 to Study 2. One reason may be that intervention-seeking samples, compared to community samples, exhibit different intensities of AB. That is, the overall effects may have been stronger for Study 1 as these participants were, on average, more distressed and impaired. Additionally, differences in trauma-specific inclusion criteria (i.e., Study 1 required a history of childhood interpersonal trauma, whereas Study 2 did not require a specific trauma-type) might explain these differences. In a meta-analysis, Cisler et al. (2011) found that the relation between PTSD and AB (at least as measured by the emotional Stroop task) was greater for individuals who experienced an assaultive rather than non-assaultive trauma and other studies have highlighted the specific cognitive effects of childhood trauma (Van Der Kolk, 2003). One twin study also found that genetic factors play a larger role on PTSS for assaultive relative to non-assaultive traumas (Jang et al., 2007), suggesting that there may be different etiological pathways for developing PTSS depending on the type of trauma experienced. It is therefore possible that the heterogeneity in traumas combined with the present study not employing trauma-specific stimuli (e.g., specific, interpersonal cues) contributed to the null results for PTSS tested in Aim 2.

Although it is somewhat puzzling that our tests of Aim 2 did not replicate prior research showing a strong relationship between PTSS and AB (Bar-Haim et al., 2010; Cisler et al., 2011), this may be explained by methodological differences. For example, prior studies reporting stronger associations between AB and PTSD often used unmasked faces, other AB tasks (e.g., emotional Stroop), and/or did not examine specific AB components (Cisler et al., 2011).

Interestingly, much of the literature on AB highlights a vigilant-avoidant theory of anxiety, which posits that individuals with greater anxiety initially orient to a threatening stimuli quickly, but subsequently avoid threatening stimuli in order to reduce their discomfort–particularly when AB is measured in an aversive context (Garner et al., 2006). This theory has also been applied to the effects of trauma-exposure (Bar-Haim et al., 2010), albeit less so. The present finding of elevated orientation to threat suggest that at least the 'vigilance' component of the theory may be relevant to understanding effects of trauma-exposure. Moreover, it is possible that the vigilant component to threat reactivity occurs as an early threat-detection process, and other features (e.g., avoidance, difficulty disengaging) occur later. Future work incorporating both early and later measures of attention is needed to fully test the vigilance-avoidance theory in PTSD/PTSS.

There are several notable limitations to this study. First, although the present study attempted to examine whether effects generalized across two independent samples and was larger than many prior studies (Choi et al., 2012; Shechner et al., 2012), neither sample size individually was substantially large, potentially preventing the detection of small effects. Second, as mentioned, Study 1 and Study 2 samples contained varying trauma types. Third, the aversive context was not trauma-specific. Individuals with PTSS may show a heightened response to trauma-specific cues, but not aversive contexts more broadly. Fourth, a RT measure may not be sensitive enough to detect subtle, group differences in automatic AB. Fifth, there were age differences between the two samples-participants in Study 1 were somewhat older than those in Study 2. There is some evidence that AB towards unmasked, positive stimuli is impacted in healthy, older adults (e.g., age 60+; Bi and Han, 2015; Namaky et al., 2017); however, it is unclear how (a) this research applies to middle-aged adults (such as those in Study 1), (b) this might extend to a masked dot-probe paradigm, or (c) the effect of trauma impacts SST. Sixth, the majority (94%) of Study 1 participants had a comorbid Substance Use Disorder (SUD) diagnosis, where only a portion (35%) of Study 2 did. Some research suggests that AB differences in SUD are due to lowered inhibitory control, which could influence greater orientation in Study 1 (Field and Cox, 2008). Lastly, it is possible that the reliability of the dot-probe metrics may be contributing to the inconsistent results. Evans and Briton (2018) and Price, Brown, and Siegle (2019) have proposed new reaction time measures of AB from dot-probe that have better psychometric properties than the traditional scoring of dot-probe reaction time used in the present study.

Table 2
Relation between PTSS, context and attentional-bias metrics.

	AB		Orientation		Disengagement	
	Study 1	Study 2	Study 1	Study 2	Study 1	Study 2
Main Effect of PTSS	-.00011	-.00064	.0047	-.0039	-.0047	.0016
Interaction of PTSS and Context (safe v. aversive)	-.013	.0099	-.0013	.0065	-.012	.0017

Note: All values are standardized beta weights and are not adjusted for covariates. No results in this analysis were statistically significant (i.e., $p < .05$). In Study 1, the significance pattern remained whether or not models included a covariate of WHODAS general disability and/or sex; and in Study 2, the significance pattern remained whether or not models covaried for sex and/or gender and/or WSAS. Beta values presented do not include any combination of covariates. PTSS scores from both studies were z-scored for ease of comparison. AB = Overall attentional-bias metric (incongruent-congruent). Orientation = Neutral-Congruent. Disengagement = Incongruent-Neutral.

In sum, though the AB literature is robust, the specifics about which facet of AB, as well as whether these processes occur during early- or late-threat detection and which are associated with which PTSD symptoms is unclear. This study contributes to the existing literature by (a) investigating AB under both safe and aversive contexts, (b) examining AB to masked faces to evaluate early threat detection, and (c) attempting to generalize findings across trauma resiliency-seeking and community samples. Results highlight that AB appears to be stronger in treatment-seeking samples, and this difference is especially pronounced when AB is assessed in an aversive environment. Future studies should continue this work in larger samples with varying intensities of PTSS, as well as comparing masked and unmasked dot-probe under aversive and safe contexts. This could help clarify the mechanisms implicated in how trauma-exposed individuals develop symptoms.

CRediT authorship contribution statement

Elyse R. Shenberger: Writing – original draft, Formal analysis, Methodology. **Carter J. Funkhouser:** Writing – review & editing, Formal analysis, Investigation. **Randy Boley:** Project administration, Investigation. **Alyson K. Zalta:** Funding acquisition, Writing – review & editing. **Stewart A. Shankman:** Writing – review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

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References

American Psychiatric Association, 2013. DSM-5 diagnostic classification. Diagnostic and Statistical Manual of Mental Disorders. American Psychiatric Association. https://doi.org/10.1176/appi.books.9780890425596.x00diagnosticclassification.

Bar-Haim, Y., Holoshitz, Y., Eldar, S., Frenkel, T.I., Muller, D., Charney, D.S., Pine, D.S., Fox, N.A., Wald, I., 2010. Life-threatening danger and suppression of attention bias to threat. Am. J. Psychiatry 167 (6), 694–698. https://doi.org/10.1176/appi.ajp.2009.09070956.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M.J., van IJzendoorn, M. H., 2007. Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. Psychol. Bull. 133 (1), 1–24. https://doi.org/10.1037/0033-2909.133.1.1.

Bi, D., Han, B., 2015. Age-related differences in attention and memory toward emotional stimuli. PsyCh J. 4 (3), 155–159. https://doi.org/10.1002/pchj.99.

Blevins, C.A., Weathers, F.W., Davis, M.T., Witte, T.K., Domino, J.L., 2015. The posttraumatic stress disorder checklist for DSM-5 (PCL-5): development and initial psychometric evaluation. J. Trauma. Stress 28 (6), 489–498. https://doi.org/10.1002/jts.22059.

Buckley, T.C., Blanchard, E.B., Neill, W.T., 2000. Information processing and PTSD: a review of the empirical literature. Clin. Psychol. Rev. 20 (8), 1041–1065. http://www.ncbi.nlm.nih.gov/pubmed/11098399.

Cavanagh, S.R., Urry, H.L., Shin, L.M., 2011. Mood-induced shifts in attentional bias to emotional information predict ill- and well-being. Emotion 11 (2), 241–248. https://doi.org/10.1037/a0022572.

Choi, J.M., Padmala, S., Pessoa, L., 2012. Impact of state anxiety on the interaction between threat monitoring and cognition. Neuroimage 59 (2), 1912–1923. https://doi.org/10.1016/j.neuroimage.2011.08.102.

Cisler, J.M., Wolitzky-Taylor, K.B., Adams, T.G., Babson, K.A., Badour, C.L., Willems, J. L., 2011. The emotional stroop task and posttraumatic stress disorder: a meta-analysis. Clin. Psychol. Rev. 31 (5), 817–828. https://doi.org/10.1016/j.cpr.2011.03.007.

Correa, K.A., Liu, H., Shankman, S.A., 2019. The role of intolerance of uncertainty in current and remitted internalizing and externalizing psychopathology. J. Anxiety Disord. 62, 68–76. https://doi.org/10.1016/j.janxdis.2019.01.001.

Egloff, B., Hock, M., 2003. Assessing attention allocation toward threat-related stimuli: a comparison of the emotional stroop task and the attentional probe task. Personal. Individ. Differ. 35, 475–483.

Field, M., Cox, W.M., 2008. Attentional bias in addictive behaviors: a review of its development, causes, and consequences. In: Drug and Alcohol Dependence, 97. Elsevier, pp. 1–20. https://doi.org/10.1016/j.drugalcdep.2008.03.030.

First, M.B., Williams, J.B.W., Karg, R.S., Spitzer, R.L., 2015. Structured Clinical Interview for DSM-5-Research Version (SCID-5 for DSM-5, Research Version; SCID-5-RV). American Psychiatric Association, Arlington, VA.

Garner, M., Mogg, K., Bradley, B.P., 2006. Orienting and maintenance of gaze to facial expressions in social anxiety. J. Abnorm. Psychol. 115 (4), 760–770. https://doi.org/10.1037/0021-843X.115.4.760.

Hedger, N., Gray, K.L.H., Garner, M., Adams, W.J., 2016. Are visual threats prioritized without awareness? A critical review and meta-analysis involving 3 behavioral paradigms and 2696 observers. Psychol. Bull. 142 (9), 934–968. https://doi.org/10.1037/bul0000054.

Jang, K.L., Taylor, S., Stein, M.B., Yamagata, S., 2007. Trauma exposure and stress response: exploration of mechanisms of cause and effect. Twin Res. Hum. Genet. 10 (4), 564–572. https://doi.org/10.1375/twin.10.4.564.

Kilpatrick, D.G., Resnick, H.S., Milanak, M.E., Miller, M.W., Keyes, K.M., Friedman, M.J., 2013. National estimates of exposure to traumatic events and PTSD prevalence Using DSM-IV and DSM-5 criteria. J. Trauma Stress 26 (5), 537–547. https://doi.org/10.1002/jts.21848.

Kukull, W.A., Ganguli, M., 2012. Generalizability: the trees, the forest, and the low-hanging fruit. Neurology 78 (23), 1886–1891. https://doi.org/10.1212/WNL.0b013e318258f812.

Lavie, N., 1995. Perceptual load as a necessary condition for selective attention. J. Exp. Psychol. Hum. Percept. Perform. 21 (3), 451–468. https://doi.org/10.1037/0096-1523.21.3.451.

Lovibond, P.F., Lovibond, S.H., 1995. The structure of negative emotional states: comparison of the depression anxiety stress scales (dass) with the beck depression and anxiety inventories. Behav. Res. Ther. 33 (3).

MacLeod, C., Mathews, A., Tata, P., 1986. Attentional bias in emotional disorders. J. Abnorm. Psychol. 95 (1), 15–20. https://doi.org/10.1037/0021-843X.95.1.15.

Namaky, N., Beltzer, M.L., Werntz, A.J., Lambert, A.E., Isaacowitz, D.M., Teachman, B. A., 2017. Moderators of age effects on attention bias toward threat and its association with anxiety. J. Affect. Disord. 216, 46–57. https://doi.org/10.1016/j.jad.2016.10.048.

Pineles, S.L., Shipherd, J.C., Mostoufi, S.M., Abramovitz, S.M., Yovel, I., 2009. Attentional Biases in PTSD: More Evidence for Interference. Behaviour Research and.

Price, R.B., Kuckertz, J.M., Siegle, G.J., Ladouceur, C.D., Silk, J.S., Ryan, N.D., Dahl, R.E., Amir, N., 2015. Empirical recommendations for improving the stability of the dot-probe task in clinical research. Psychol. Assess. 27 (2), 365–376. https://doi.org/10.1037/pas0000036.

Rauch, S.L., Whalen, P.J., Shin, L.M., McInerney, S.C., MacKlin, M.L., Lasko, N.B., Orr, S. P., Pitman, R.K., 2000. Exaggerated amygdala response to masked facial stimuli in posttraumatic stress disorder: a functional MRI study. Biol. Psychiatry 47 (9), 769–776. https://doi.org/10.1016/S0006-3223(00)00828-3.

Shechner, T., Pelc, T., Pine, D.S., Fox, N.A., Bar-Haim, Y., 2012. Flexible attention deployment in threatening contexts: an instructed fear conditioning study. Emotion 12 (5), 1041–1049. https://doi.org/10.1037/a0027072.

Tottenham, N., Tanaka, J., Leon, A., McCarry, T., Nurse, M., Hare, T., Marcus, D., Westerlund, A., Casey, B., Nelson, C., 2009. The nimstim set of facial expressions: judgments from untrained research participants. Psychiatry Res. 168 (3), 242–249. https://doi.org/10.1016/j.psychres.2008.05.006.

Üstün, T.B., Chatterji, S., Kostanjsek, N., Rehm, J., Kennedy, C., Epping-Jordan, J., Saxena, S., von Korff, M., Pull, C., 2010. Developing the world health organization disability assessment schedule 2.0. Bull. World Health Organ. 88 (11), 815–823. https://doi.org/10.2471/BLT.09.067231.

Van Der Kolk, B.A., 2003. The neurobiology of childhood trauma and abuse. Child Adolesc. Psychiatr. Clin. 12, 293–317. https://doi.org/10.1016/S1056-4993(03)00003-8.

Whalen, P.J., Rauch, S.L., Etcoff, N.L., McInerney, S.C., Lee Michael, B., Jenike, M.A, 1998. Masked presentations of emotional facial expressions modulate amygdala activity without explicit knowledge. J. Neurosci. 18 (1), 411–418. https://doi.org/10.1523/jneurosci.18-01-00411.1998.

Zahra, D., Qureshi, A., Henley, W., Taylor, R., Quinn, C., Pooler, J., Hardy, G., Newbold, A., Byng, R., 2014. The work and social adjustment scale: reliability, sensitivity and value. Int. J. Psychiatry Clin. Pract. 18 (2), 131–138. https://doi.org/10.3109/13651501.2014.894072.