Research Article

POSTDEPLOYMENT THREAT-RELATED ATTENTION BIAS INTERACTS WITH COMBAT EXPOSURE TO ACCOUNT FOR PTSD AND ANXIETY SYMPTOMS IN SOLDIERS

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Background: *Recent studies suggest that assessment of threat-related attention bias may be useful in identifying soldiers at risk for clinical symptoms. The present study assessed the degree to which soldiers experienced combat events and showed attentional threat avoidance affected their reported levels of posttraumatic stress disorder (PTSD) and anxiety symptoms.* **Methods:** *Four months after a combat deployment to Iraq, 63 US soldiers completed a survey assessing combat exposures and clinical symptoms as well as a dot-probe task assessing threat-related attention bias.* **Results:** *Significant three-way interactions regressing threat reaction times (RTs), neutral RTs, and combat exposure on PTSD and anxiety symptoms were observed. Specifically, soldiers with high levels of combat exposure, who were more likely to demonstrate attentional bias away from threat, were also more symptomatic.* **Conclusion:** *These results demonstrate the potential of threat-related attention bias as a behavioral marker of PTSD and anxiety symptoms in a high-risk military occupational context. Depression and Anxiety 00:1–6, 2013.*

Key words: *attention bias; anxiety; combat exposure; difference scores; polynomial regression; PTSD*

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Biased processing of threat stimuli has been shown to confer vulnerability to anxiety and stress-related psychopathology.[1–6] However, much less is known about the effects of stress on threat processing and the ways in which threat processing and environmental stress interact to affect anxiety and posttraumatic symptoms. Recent studies indicate that threat-related attention bias is modulated by stress exposure in nonclinical civilian samples experiencing war zone stress,[7,8] in nonanxious students exposed to a laboratory induced stress,[9,10] and in soldiers undergoing a taxing combat simulation drill.[11] These studies show that when exposed to external danger, individuals tend to actively shift attention away from minor threats presented to them in the context of a computerized attention task, and that this attentional threat avoidance is associated with heightened posttraumatic and anxiety symptoms. Attentional threat avoidance may reduce some aspects of psychological distress in the short run but at the cost of elevated symptoms.[12,13]

Two recent studies suggest that the assessment of threat-related attention bias may be useful in identifying soldiers at risk for post-traumatic stress disorder (PTSD) and anxiety symptoms.[14,15] Beevers et al.[14] found that predeployment eye-gaze bias moderated the association between war zone stress exposure and PTSD symptoms. Specifically, soldiers who showed shorter mean fixation time to threat faces prior to deployment and were later exposed to war zone stress reported higher PTSD symptoms during deployment. Similarly, soldiers who displayed attentional threat avoidance on a word-based dot-probe attention task administered before deployment and were then deployed in high combat exposure zones were at risk for PTSD symptoms during deployment.[15] Together, these longitudinal findings suggest that an attentional predisposition to avoid threat stimuli interacts with combat exposure to increase risk for PTSD and anxiety symptoms.

In the present study, we extend previous work to enhance our understanding of the mechanisms related to military mental health during the key postdeployment period[16] and examined whether the associations among attentional threat avoidance (as previously measured predeployment by Beevers et al.[14] and Wald et al. [15]), combat exposure, and PTSD and anxiety symptoms are also evident 4 months postdeployment. Based on Beevers et al. [14] and Wald et al. [15], we expected soldiers who experienced more combat events and showed attentional threat avoidance to report higher levels of PTSD and generalized anxiety symptoms.

METHOD

PARTICIPANTS

The present study was approved by the Walter Reed Army Institute of Research Institutional Review Board and all participants provided written informed consent. Sixty-three soldiers from the headquarters element of a US Army operational unit participated in the study 4 months following their 12-month deployment to Iraq. Participation involved completing an anonymous survey followed by the measurement of threat-related attention bias using the dot-probe attention task. Two respondents failed to complete all 17 items of the PCL questionnaire, thereby reducing the sample size for analyses of PTSD symptoms to 61 respondents. Eighty-six percent of the sample was male. As would be expected from headquarters element, the sample tended to be older (71% above the age of 24); of higher rank (63% Noncommissioned Officer or Officers), and reported fewer combat exposures ($M = 2.07$, $SD = 2.19$, maximum = 10) than typical Army samples from operational units.[17]

MEASURES

Combat Exposure. Combat exposure was assessed with the 34-item combat experiences scale.[17] The possible range of scores is from 0 to 34 with higher scores indicating more exposure to combat experiences. Combat exposure was used as a continuous measure for analysis. For graphical presentation (Fig. 2), combat exposure was divided into low and high combat based on a median split.

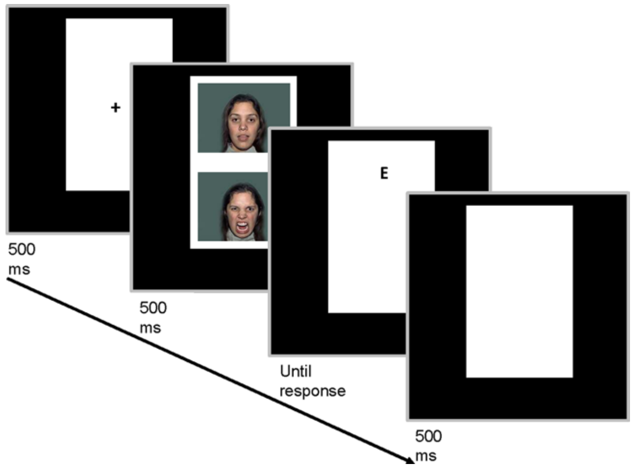

Figure 1. Sequence of events in a dot-probe trial: fixation (500 ms); face pair (500 ms); target probe until response; and intertrial interval (500 ms).

PTSD Symptoms. The 17-item PTSD Checklist (PCL [18,19]) was used to assess PTSD symptoms. Participants rated symptoms in the last month on a 5-point scale (1 = *not at all*, 5 = *extremely*) with possible scores ranging from 17 to 85. This measure has been validated and has been used widely in military samples.[20]

Generalized Anxiety Symptoms. The seven-item measure of generalized anxiety disorder (GAD-7) symptoms was used to assess generalized anxiety symptoms.[21] Participants rated symptoms in the last month on a 4-point scale (1 = *not at all*, 4 = *nearly every day*). The mean score of the seven items was computed (range 1–4).

Threat-Bias Assessment: The Dot-Probe Task. Threat-related bias was assessed using a variant of the dot-probe task.[22] In the task, pairs of face stimuli, one with emotional valence (happy or angry) and one neutral, were presented simultaneously, followed by a target probe that appeared in the location vacated by one of the faces (Fig. 1). Participants had to identify the probe as quickly as possible without compromising accuracy.

The face stimuli were photographs of 12 different actors (six females) taken from the NimStim stimulus set.[23] Three different photographs of each actor were selected, depicting angry, happy, and neutral expressions. Each face was placed on a green rectangle background (40 × 30 mm). Face pairs were same-actor combinations of neutral-angry (NA), neutral-happy (NH), or neutral-neutral (NN) expressions. The face photographs were presented vertically with equal distance from the top and bottom of the fixation cross, and a distance of 14 mm between them. The top photograph was positioned 20 mm from the top edge of the screen. The screen background was black, although both photographs were surrounded by a single 5 × 8 cm white rectangle.

Each trial began with a fixation display (500 ms; white cross 2 × 2 cm), followed by a pair of faces (500 ms). Immediately following the presentation of the face pair, a target probe (letter *E* or *F*; font Arial, size 14, bold) appeared at the location previously occupied by one of the faces. Participants had to determine which letter appeared by pressing one of two prespecified buttons on a mouse. The probe remained on the screen until response. A new trial began 500 ms following response.

One hundred and twenty trials were presented: 48 NA trials, 48 NH trials, and 24 NN trials (all randomly mixed in presentation). Across

TABLE 1. Posttraumatic stress disorder symptoms, generalized axiety disorder symptoms, and threat-bias indices by combat exposure intensity

	Low- combat exposure		High- combat exposure		Overall	
Index	*M* (*SD*)	Range	*M* (*SD*)	Range	*M* (*SD*)	Range
Combat experience	0.72 (0.46)	0–1	3.48 (2.39)	2–10	2.08 (2.19)	0–10
Posttraumatic stress disorder symptoms						
PTSD checklist (PCL) score	22.11 (9.4)	17–55	24.48 (7.8)	17–47	23.28 (8.7)	17–55
Generalized anxiety disorder symptoms						
GAD-7 Score	1.28 (0.54)	1–4	1.55 (0.67)	1–4	1.41 (0.62)	1–4
Threat-bias assessment, dot-probe task						
Alternative difference score (ms)	−5 (42)	−125–88	6 (42)	−73–105	0 (42)	−125–105
Reaction time, neutral trials (ms)	612 (91)	466–952	627 (111)	482–959	620 (101)	466–959
Reaction time for threat stimuli (ms)	617 (87)	503–864	621 (105)	493–969	619 (95)	493–969
Accuracy, neutral trials (%)	97.8 (0.04)	87.5–100	96.8 (0.04)	87.5–100	97.3 (0.04)	87.5–100
Accuracy, for threat stimuli (%)	97.5 (0.03)	85.4–100	97.3 (0.03)	83.3–100	97.4 (0.03)	83.3–100

all face pair types, trials were counterbalanced with respect to actor identity, actor gender, emotion valence location, probe location, and probe type. Trials with reaction times (RTs) <150 ms or >2,000 ms or incorrect response were excluded. Then, for each participant, we calculated mean RT per trial type and excluded trials with RTs deviating by >2.5 *SD*s from the mean.

DATA ANALYSIS

On the dot-probe task, threat-related attention bias is typically assessed by contrasting RTs from neutral trials versus threat trials and creating a difference score—an attention bias score. These attention bias scores are subsequently regressed on outcome variables such as PTSD and anxiety symptoms.

Although the use of difference scores is conceptually appealing, such scores are known to have analytic shortcomings.[24–26] First, the reliability of difference scores (including attention bias scores derived from the dot-probe task) has been questioned. Under certain psychometric assumptions, low reliability is exacerbated by having highly correlated components[27]; indeed, RT components of the dot-probe task tend to be highly correlated. For instance, in the current study the correlation between average RT for the neutral trials and the threat trials is .91. Second, difference scores omit a large amount of information by imposing a highly restrictive regression model.[28] Mathematically, a difference score is equivalent to constraining the estimated betas of both components composing the difference score such that the components have identical (but opposite signed) values.

Several alternatives have been suggested to combine difference score elements to include estimating both main effects and their interaction[24]; however, Edwards[28,29] has shown that the coverage of the surface space represented by differences between the two components is best represented in a model that regresses the outcome on (1) both neutral and threat RT main effects, (2) the two-way interaction between the two RTs, and (3) the quadratic terms for each RT effect. We therefore apply this model and augment its interpretation by plotting the three-dimensional surface associated with significant components of the model. In the figures, combat exposure is dichotomized into high and low exposure using one standard deviation above and below the sample's mean.

We applied two specific models, one for generalized anxiety symptoms (GAD-7) and one for PTSD symptoms (PCL). Both models included two- and three-way interactive effects involving mean neutral and threat trial RTs and combat exposure, and used fully standardized variables to facilitate interpretation. The three-way interaction (Combat Exposure × Threat RT × Neutral RT) tests the hypothesis that soldiers who experienced more combat events and show attentional threat avoidance (i.e., faster RTs to neutral relative to threat trials) will report higher levels of PTSD and generalized anxiety symptoms. For completeness, all corresponding two-way interactions involving combat, threat RT, and neutral RT are included in the model (Table 3). Typical attention bias difference score models are also presented for comparison. Based on previous studies,[14–16,30] one-tailed tests were conducted for combat exposure, the three-way interaction and the alternative difference score analysis.

RESULTS

Tables 1 and 2 present the means and intercorrelations for the outcome measures. Table 3 presents the results of the polynomial regression models predicting PCL and GAD-7 scores from combat exposure, threat, and neutral trials RTs on the dot-probe task.

PTSD SYMPTOMS

A significant three-way interaction involving combat exposure, threat RTs, and neutral RTs was found ($t = -1.77$, $P < .05$ one-tailed). Figure 2A indicates that under low combat exposure, threat and neutral RTs appeared unrelated to PTSD symptoms. In contrast, Fig. 2B suggests that under high combat exposure participants slow to respond to targets in threat locations (long RT values) and fast to respond to targets in neutral locations (short RT values) reported high PTSD symptoms. The pattern of high threat RT combined with low neutral RT is equivalent to attentional threat avoidance. In the alternative difference-score analysis (not shown), a significant interaction between the difference-based bias score and combat exposure was also detected, $t(57) = -1.93$; $P = .03$, one-tailed. Consistent with the three-way interaction reported in Table 3 for PCL scores, participants who reported higher combat exposure and showed attentional threat avoidance reported more PTSD symptoms.

GENERALIZED ANXIETY SYMPTOMS

A significant three-way interaction involving combat exposure, threat RTs, and neutral RTs was found

TABLE 2. Correlations among outcome variables

Variable		1	2	3	4	5
1	Reaction time neutral trial	–				
2	Reaction time threat stimulus	0.91**	–			
3	Combat exposure	0.04	0.01	–		
4	PCL	0.29*	0.28*	0.26*	–	
5	GAD-7	0.25*	0.21	0.26*	0.78**	–

*$P < .05$; **$P < .001$.

($t = -1.98$, $P < .05$ one-tailed). As with the PCL results, under low combat (Fig. 2C), threat and neutral RTs appeared unrelated to generalized anxiety symptoms. Under high combat (Fig. 2D), participants slow to respond to threat appeared to have high generalized anxiety symptoms across the range of neutral RT values. Finally, using the alternative difference-score analysis (not shown) the interaction between the bias score and combat exposure was not significant, $t(59) = -1.42$; $P = .08$, one-tailed.

DISCUSSION

Results of the present study demonstrate that soldiers who reported more combat exposures and show attentional threat avoidance (i.e., slower responses to threat trials relative to neutral trials) also reported higher levels of PTSD and generalized anxiety disorder symptoms. Our findings replicate the pattern of results seen by both Beevers et al.[14] and Wald et al.,[15] but involved different tasks (dot-probe vs. eye-gaze tracking) and different stimuli (faces vs. words used as stimuli), respectively. In addition, the results of the present study are unique in that they are the first demonstration of the interaction between combat exposure, attentional threat avoidance, and behavioral health symptoms in soldiers during the postdeployment period.

These findings suggest that attentional avoidance of threat stimuli may be a robust phenomenon among symptomatic populations who are either experiencing or have recently experienced highly stressful combat events. For example, the relationship between combat exposure, attentional threat avoidance, and PTSD and generalized anxiety disorder symptoms was found despite the relatively low levels of combat exposures and the subclinical levels of symptoms reported in this relatively small sample. Furthermore, the pattern of results was documented in a population of combat veterans that was older and higher ranking, and thus perhaps more resilient[17] than those in previous reports. Generally, a restricted range on key variables such as combat exposure, PTSD, and anxiety limit one's ability to detect significant effects. Thus, the findings with this restricted sample suggest that the phenomenon is quite robust. However, future studies should further examine the attentional threat avoidance phenomenon in longitudinal designs and in combat veterans who experienced higher levels of combat.

The present findings in combat veterans are all the more interesting because threat-related attentional patterns typically seen in patients diagnosed with PTSD reflect enhanced vigilance (a bias toward threat stimuli) rather than the pattern of threat avoidance seen in the current study.[1] Based on the findings in military samples to date, it appears that patterns of threat-related attentional bias among military respondents placed in high-stress situations differs from threat-related attentional bias patterns typically seen among clinically anxious populations. Although one might hypothesize that these differences may be related to the amount of time that elapsed between when the trauma was experienced and attention testing (many months in the past for clinical populations vs. before or in combat for military populations), the current results obtained in combat veterans 4 months following deployment suggest that this may not be the case. It may be that in the occupational context of a military deployment, attentional bias toward threat

TABLE 3. Polynomial regression models predicting PCL and GAD-7 scores from combat exposure, threat, and neutral reaction times on the dot-probe task

	PCL			GAD-7		
Variable	Estimate	*SE*	*t* value	Estimate	*SE*	*t* value
Intercept	0.08	0.13	0.56	0.34	0.16	2.09*
Combat exposure[a]	0.83	0.26	3.20**	1.07	0.32	3.36**
Threat reaction time	0.51	0.27	1.09	0.74	0.33	2.23*
Neutral reaction time	−0.24	0.26	−0.93	−0.33	0.32	−1.03
Threat (quadratic)	−0.02	0.45	−0.04	−1.19	0.56	−2.13*
Neutral (quadratic)	0.01	0.56	0.01	−1.08	0.70	−1.54
Combat × Threat	1.21	0.51	2.39*	0.83	0.63	1.32
Combat × Neutral	−1.34	0.50	−2.70*	−0.79	0.61	−1.29
Threat × Neutral	−0.01	1.03	−0.01	2.29	1.28	1.79
Combat × Threat × Neutral[a]	−0.29	0.16	−1.77*	−0.40	0.20	−1.98*

[a]One-tailed test.
*$P < .05$; **$P < .001$.

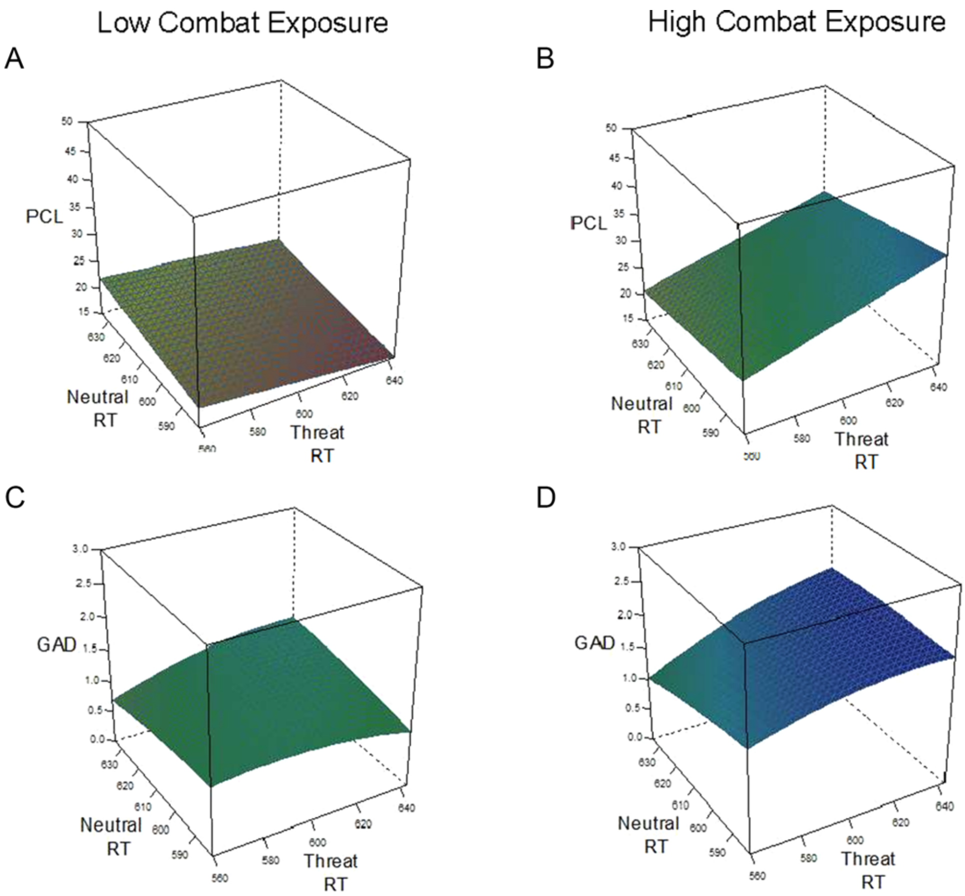

Figure 2. Response surfaces representing three-way interactions between combat exposure (categorized into low or high based on a median split), mean RT in threat trials (threat RT), and mean RT in neutral trials (neutral RT) on the dot-probe task, and PTSD symptoms (panels A and B) or generalized anxiety symptoms (panels C and D). PCL, PTSD Checklist; GAD, generalized anxiety disorder.

is a result of military training and is indicative of more successful adjustment overall[15,31] and may explain why the results differ from studies of civilian-based clinical populations (in which bias toward threat is indicative of less successful adjustment).

Military training that prepares soldiers for a combat deployment purposefully encourages vigilance and attention directed at identifying potential threats (e.g., Improvised Explosive Devices, snipers, and ambushes). Vigilance toward potential threats is expected to enhance survival and is deemed adaptive for soldiers in a combat environment. This kind of vigilance is consistent with an attentional bias toward threat, and thus an indication of successful adaptation to the occupational context. Future research should examine whether the pattern of threat-related attentional bias seen in combat veterans following high levels of combat is more similar to the patterns seen in clinical populations than nonclinical populations.

As a secondary contribution, the present study describes a novel approach to the analysis of threat-related attention biases derived from the dot-probe task. Specifically, the study illustrates the value of modeling the individual RT components rather than RT difference scores. Modeling both components of RT in a polynomial regression model allows one to maintain much of the information that is discarded when using difference scores. Although both approaches can provide similar results (as seen for PTSD symptoms in the present study), the polynomial regression model may be more sensitive in detecting relationships otherwise masked when using the difference scores approach (as seen for generalized anxiety symptoms), underscoring the value of modeling both RT components instead of the more restrictive difference scores to analyze attention biases with the dot-probe task. Despite these strengths, one limitation in our current study is that the sample size was not powered for post hoc examinations of the three-way interaction.

In conclusion, the present results support continued efforts to investigate patterns of threat-related attention bias to determine how threat processing may be altered by periods of high risk. In the long-term, it is possible that interventions to ameliorate the effects of combat or other high-intensity stress may be developed by adapting attention bias modification strategies demonstrated to be effective for treating anxiety disorders.[32–34]

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