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Acute delivery of attention bias modification training (ABMT) moderates the association between combat exposure and posttraumatic symptoms: A feasibility study

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ABSTRACT

Combat deployment enhances risk for posttraumatic stress symptoms. We assessed whether attention bias modification training (ABMT), delivered immediately prior to combat, attenuates the association between combat exposure and stress-related symptoms. 99 male soldiers preparing for combat were randomized to receive either an ABMT condition designed to enhance vigilance toward threat or an attention control training (ACT) designed to balance attention deployment between neutral and threat words. Frequency of combat events, and symptoms of PTSD and depression were measured prior to deployment and at a two-month follow-up.

Regression analysis revealed that combat exposure uniquely accounted for 4.6% of the variance in stress-related symptoms change from baseline to follow-up and that the interaction between ABMT and combat exposure accounted for additional 5.4% of the variance. Follow-up analyses demonstrate that ABMT moderated the association between combat exposure and symptoms. ABMT appear to have potential as a preventative intervention to reduce risk for stress-related symptoms associated with combat exposure.

1. Introduction

Combat exposure increases risk for new-onset of various stress-related symptoms, including depression (Wells et al., 2010), anxiety (McNally, 2003), and Acute Stress Disorder (presence of intrusive traumatic memories, avoidance of traumatic reminders, hyperarousal, and alterations in mood) (Kok, Herrell, Thomas, & Hoge, 2012). If Acute Stress Disorder symptoms last for more than one month, posttraumatic stress disorder (PTSD) is diagnosed (DSM-5; American Psychiatric Association, 2013). Although efficacious treatments for PTSD exist (Bradley, Greene, Russ, Dutra, & Westen, 2005; Steenkamp and Litz, 2013), less progress has been made in the domain of PTSD prevention. Most available prevention strategies target individuals in the acute aftermath of trauma (Agorastos, Marmar, & Otte, 2011; Bryant, Harvey, Dang, Sackville, & Basten, 1998; Bryant, Moulds, Guthrie, & Nixon, 2005; Feldner, Monson, & Friedman, 2007; Forneris et al., 2013; Kliem and Kroger, 2013; Shalev et al., 2012). Data from the few studies targeting primary prevention, that is before a traumatic event had occurred, suggest the need for novel approaches (Skeffington, Rees, & Kane, 2013).

Here, we test the efficacy of attention bias modification training (ABMT), a computer-based protocol designed to modify threat-related attention patterns, in reducing risk for PTSD symptoms. Different attention patterns manifest in safe and dangerous environments, where minor threats can signal impending risk for genuine danger. While anxiety is associated with an attention focus on minor threats in safe environments, in stressful environments, resilient individuals are those who exhibit attention focus on threats (Wald et al., 2013b). Moreover, in stressful environments, individuals who direct attention away from threat are at greater risk for PTSD than those who monitor and attend to threats (Bar-Haim et al., 2010b; Beevers, Lee, Wells, Ellis, & Telch, 2011; Sipos, Bar-Haim, Abend, Adler, & Bliese, 2014; Wald et al., 2013b, 2011b, 2011d). Thus, attentional threat avoidance in dangerous

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circumstances, such as combat, may come at a psychological cost (Harvey and Bryant, 2002; Lensvelt-Mulders et al., 2008; Marmar et al., 1994), and thus provide a target for primary prevention (Wald et al., 2013b). In light of recent advances in ABMT research the current study tests the hypotheses that vigilance toward minor threats induced by ABMT will attenuate the association between traumatic exposure and stress-related symptoms in combat deployed soldiers. ABMT was compared to an attention control training (ACT) condition presenting attention demands that do not favor neither threat nor neutral stimuli. This ACT condition has proved efficacious in the treatment of combat-related PTSD (Badura-Brack et al., 2015; Kuckertz et al., 2014).

We delivered ABMT or ACT to Israel Defense Forces (IDF) soldiers preparing for combat in a tactical assembly area. We then measured self-reported combat exposure and stress-related symptoms (PTSD, depression) two months later.

2. Methods

2.1. Participants

One hundred and thirty male IDF regular service soldiers (M_{age} = 20.4 years, SD = 1.27) enrolled in the study. All soldiers were from an infantry brigade preparing to deploy into combat in November 2012. At a tactical assembly area near the border soldiers were randomly assigned to receive either ABMT toward threat or ACT. Two months later 99 of these soldiers reported on their combat experiences, depressive, and PTSD symptoms (n = 45 from the ABMT group; n = 54 from the ACT group). Thirty-one participants were lost to follow-up: 18 could not be reached due to inaccuracies in their contact information; 10 could not be reached because they were either honorably discharged or reassigned to a different unit; and 3 discontinued participation.

Written informed consent was obtained from all participants. The study was approved by the Tel Aviv University Institutional Review Board and the IDF Medical Corps Ethics Committee.

2.2. Study settings

Baseline self-reports of depression and PTSD symptoms and the attention training session were conducted at tactical assembly areas near the border with the use of laptop computers. Soldiers were making final preparations and checks prior to moving to the line of departure on the border when the questionnaires were completed and attention was trained. The two-month follow-up was conducted via structured telephone interview during which participants reported on PTSD and depression symptoms and on experienced combat events.

2.3. Study intervention

ABMT (Bar-Haim, 2010; Hakamata et al., 2010) designed to shift attention toward threat served as active intervention whereas ACT, not designed to shift attention patterns but rather to balance attention deployment between neutral and threat words, served as control. Both conditions used a variant of the probe detection task (MacLeod, Mathews, & Tata, 1986; Wald et al., 2013b) and delivered 304 training trials in two blocks (152 in each block) with a short break of two minutes in-between. The entire procedure lasted 16 min. The sequence of events in each training trial is depicted in Fig. 1. Each trial began with a centrally presented fixation display "+++" (500 ms), immediately followed by a word pair written in 1-cm high white block text (1000 ms). One word was threat-related (e.g., DEAD) and the other was neutral (e.g., DATA). One word appeared directly above, while the other appeared directly below the location vacated by the preceding fixation signal. The

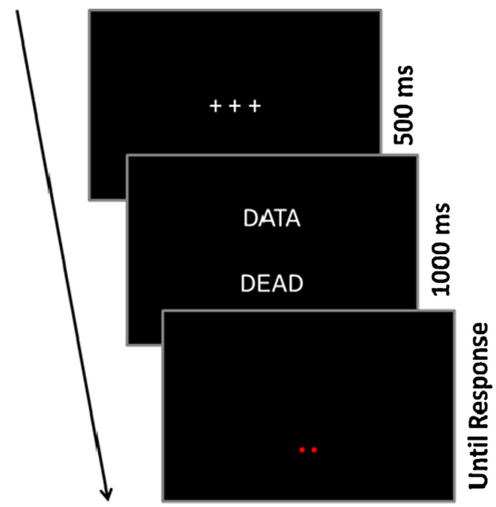

Fig. 1. Sequence of events in the dot-probe task presenting a threat-congruent target location.

threat and neutral words of each word-pair had the same number of letters and the same frequency of usage in the Hebrew language. The word-pair was then replaced by a target probe that appeared in either of the two locations vacated by the words. Target type (either one dot or two dots) was determined randomly on each trial and participants had to indicate the target type as quickly as possible without compromising accuracy. Upon response the screen cleared and the next trial began 500 ms later. We used words because we think they could better tap into the soldiers' semantic network related to potential trauma and consequently better impact their attention in relation to their yet to be experienced traumatic events. Neuroimaging evidence indicate that word-based dot probe ABM can induce both behavioral and neural changes (Browning, Holmes, Murphy, Goodwin, & Harmer, 2010). Moreover, the rational for this study is based on our previous findings of threat-related attentional suppression under threat (Bar-Haim et al., 2010a; Wald et al., 2013a, 2011a, 2011c), all of which relied on word stimuli.

For soldiers in the ABMT condition targets always appeared at the location previously occupied by the threat words. Consequently, target location was reliably associated with threat location. Because attending to this contingency can assist in task performance, an implicitly learned bias to attend toward threat is assumed to be gradually induced. In contrast, soldiers in the ACT condition were exposed to the exact same word pairs as did the soldiers in the ABMT condition, with the exception that target location was fully counterbalanced with regard to threat word location. Thus, no association existed between target location and threat word location.

2.4. Outcome measures

Symptoms of PTSD and depression were measured twice: at baseline and at a two-month follow-up. PTSD symptoms were evaluated with the use of the 17-item National Center for PTSD Checklist of the Department of Veterans Affairs (PCL) (Blanchard, JonesAlexander, Buckley, & Forneris, 1996). Symptoms were related to stressful events that the participants experienced during their deployment. Symptoms of depression were measured with the use of the 9-item self-report Patient Health Questionnaire (PHQ-9) (Kroenke, Spitzer, & Williams, 2001).

The correlations between the PCL and PHQ-9 scales were quite high at baseline (r = 0.69, p < 0.001) and at follow-up (r = 0.62, p < 0.001), and each of the two measures separately produced the same pattern of significant results. Thus for parsimony and ease

Table 1
Means and standard deviations (in parenthesis) of stress-related symptoms pre- and post-deployment and threat bias scores (reaction time, accuracy) by training group.

	Pre-deployment		Post-deployment	
	ABMT	ACT	ABMT	ACT
Depression (PHQ-9)	6.43 (5.15)	6.24 (4.89)	4.21 (4.62)	4.74 (4.11)
PTSD (PCL)	26.98 (9.19)	25.13 (9.58)	23.00 (8.28)	21.61 (5.90)
Combined stress symptoms	56.10 (28.13)	52.38 (26.96)	43.11 (22.07)	42.82 (20.33)
Mean RT threat (ms), SD		487 (98)		
Mean RT neutral (ms), SD		485 (97)		
% accuracy threat (SD)		97 (0.02)		
% accuracy neutral (SD)		98 (0.03)		
Mean threat bias score (ms), SD		−2 (17)		

of read, we combined the two scales at each time point to create a simple index of stress-related symptoms.[1] Also, the new DSM-5 diagnosis of PTSD was amended to include depressive symptoms. We used a PCL version that corresponds to DSM-4 and thought that combining the two measures provides a closer symptom description to the current DSM-5 criteria. (DSM-5, 2013). The outcome measure used in data analysis was calculated as symptoms severity score at follow-up minus symptoms severity score at baseline, with positive values reflecting increase in stress-related symptoms from baseline to follow-up.

2.5. Combat experiences

Intensity of combat exposure was measured using the Combat Experiences Scale (Hoge et al., 2004). The original scale consisted of 18 binary questions regarding experience of various combat event types. We added two event types specifically relevant to the IDF deployment context (Wald et al., 2013b).

2.6. Statistical analyses

Analyses used data only from participants who provided information at follow-up, where combat events could be reported. No differences were observed in age, years of education, and baseline depression (PHQ-9), PTSD symptoms (PCL), the different PTSD symptom clusters, and the combined stress-related symptoms index between participants who provided a full data set ($n = 99$) and participants who provided only baseline data ($n = 31$), both overall and in relation to each training group (ABMT, ACT) separately, all $ps > 0.26$. Internal reliability of PCL scores at baseline was $\alpha = 0.85$ and after deployment $\alpha = 0.88$. Internal reliability of PHQ-9 scores at baseline was $\alpha = 0.81$ and after deployment $\alpha = 0.80$. Retest reliability for the combined index was $\alpha = 0.75$.

To examine the effect of ABMT on the association between combat exposure and change in stress-related symptoms, we applied a stepwise regression model regressing training group (ABMT, ACT), combat experiences, and their interaction term on stress-related symptoms change-score from baseline to two-month post deployment follow-up. Simple slope analyses were used to estimate change in stress-related symptoms as a function of the interaction between training group and combat experiences. Simple slope tests were used to evaluate whether the relation (slope) between combat exposure and stress-related symptoms is significant for a particular value of training group type.

[1] To correct for scale differences (17–85 and 1–27 in PCL and PHQ-9, respectively) we applied the following algorithm before we combined the scales: $(100/\alpha) \times b$, where "α" refers to the maximum possible score of the questionnaire (85 and 27 for the PCL and PHQ, respectively), and "b" refers to the participant's score on the specific questionnaire.

Table 2
Regression predictors on stress-related symptoms change from baseline to post-combat.

	B	SE	95% CI	*p*
Group	5.75	6.95	−26.89 to −10.23	0.410
Exposure	5.59	1.80	2.07 to 9.16	0.002
Group × Exposure	−4.60	2.89	−8.54 to −0.66	0.031

Estimated coefficients (B), standard errors (SE), confidence intervals (CI), and significance values (p) for the regression model testing the effects of ABMT (Group) and combat exposure (Exposure) on stress-related symptoms change from baseline to post-combat.

3. Results

3.1. Combat experiences

The military operation providing the context for the current study presented a low-intensity combat experience for the studied sample, with a mean of 1.7 combat events per soldier and a range of 0–8 events. The most frequently reported events were: receiving incoming artillery, rocket, or mortar fire (38%, 38/99); shooting or directing fire at the enemy (30%, 30/99); being at a place where stones or explosive devices were thrown/detonated (21%, 21/99); being attacked or ambushed (20%, 20/99); and knowing someone who was seriously injured or killed (20%, 20/99). Soldiers in the ABMT group reported a mean of 1.98 combat events ($SD = 1.63$), whereas soldiers in the ACT group reported a mean of 1.46 combat events ($SD = 1.61$), with no difference between the groups, $p = 0.12$. Soldiers in the two groups did not differ on stress-related symptoms before deployment ($p = 0.29$).

Table 1 describes reported stress-related symptoms at the tactical assembly area and two month later when the operation was over and soldiers were deployed in a safe environment. Soldiers reported more stress-related symptoms (combined stress-related symptoms index) when exposed to enemy fire and making the final preparations to enter combat ($M = 54.01$, $SD = 27.40$) relative to when this stress was no longer pertinent at follow-up ($M = 42.95$, $SD = 22.07$), $p < 0.0001$. The next set of analyses probe the moderation of the association between combat exposure and stress-related symptoms by ABMT.

The estimated coefficients for the regression model predicting the effects of attention training type and combat exposure on change in stress-related symptoms are shown in Table 2. The overall model significantly accounted for 10% of the variance in stress-related symptoms change. Combat exposure uniquely accounted for 4.6% of the variance, $F(1, 92) = 4.34$, $p = 0.04$. The interaction term between attention training type and combat exposure accounted for additional 5.4% of the variance in stress-related symptoms change, $F(2, 92) = 4.96$, $p = 0.009$. Follow-up simple slopes analyses (Fig. 2) demonstrates that for the ACT group the slope coefficient was positive and significantly different from zero, $B = 6.24$, $p = 0.001$. This suggests that in this group, soldiers who

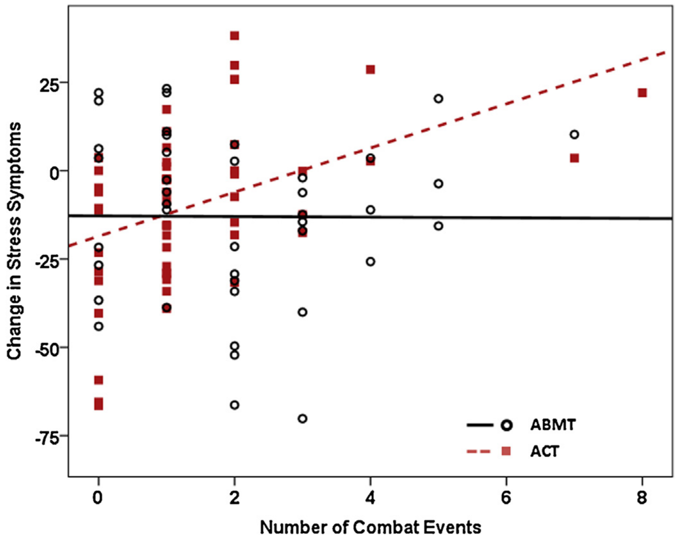

Fig. 2. Simple slopes analysis depicting the association between number of experienced combat events and change in stress symptoms from baseline to post deployment follow-up.

experienced more potentially traumatic combat events demonstrated greater elevations in stress-related symptoms. In contrast, for the ABMT group the slope coefficient was not significantly different from zero, $B = 0.09$, $p = 0.97$. This suggests that ABMT moderated the association between combat exposure and stress-related symptoms.

4. Discussion

Previous research finds an association between attentional threat avoidance and stress-related symptoms in combat-exposed soldiers (Beevers et al., 2011; Sipos et al., 2014; Wald et al., 2013b, 2011b). Findings from the current study suggest that one session of ABMT aimed to enhance attentional vigilance toward threat, moderates the association between combat exposure and stress-related symptoms. The current study further shows that acute delivery of computerized cognitive training is achievable at front-line tactical assembly areas and could be used to buffer combat-related symptoms. However, the findings also revealed that ABM accounted for only modest percentage of the measured stress-related variance. Additional factors such as traumatic history, level of education, level of pre-deployment psychopathology, as well as neurobiological factors could improve prediction and should be tested in future research.

While most studies of ABM for anxiety disorders focused on reducing attention bias to threats, the current results support the idea that attending toward threat may be adaptive in circumstances where vigilance to threat is needed and paramount to survival. In extreme situations, such as combat, even minor threat cues might signal genuine danger. Under such circumstances, it may become adaptive to be highly attentive to threat cues (LeDoux, 1995; Öhman, 1993). Shedding further light on the neural and behavioral mechanisms affected by acute stress (Admon, Milad, & Hendler, 2013; Lin et al., 2015; McEwen and Sapolsky, 1995) and the neuro-functional changes resulting from ABM and other forms of cognitive training (Britton et al., 2014; Browning et al., 2010; Cohen et al., 2016; Eldar and Bar-Haim, 2010; Sari, Koster, Pourtois, & Derakshan, 2015), could considerably impact the development of more efficacious prevention protocols (Bar-Haim and Pine, 2013).

The results of the current study should be viewed in light of some limitations. First, although exposed to some extent the overall combat intensity experienced by the current sample was quite low. Indeed, when interviewed in a safe environment at follow-up, symptoms at the group level were lower relative to those collected at the tactical assembly area before deployment to combat. It is conceivable that the ameliorating effects of ABMT would be even more robust under conditions of higher combat exposure, highlighting the adaptive nature of threat vigilance in such circumstances. Second, longer term follow-up may have revealed additional benefits or disadvantages of the attention training regimens. It is of great importance to test how long the attentional attenuation lasts and whether context discrimination learning is required. Specifically, do soldiers attend to threat while in the army and demonstrate no attentional bias while in civilian life. Third, in the current study we were able to deliver only 304 ABMT trials under rather rough field conditions. ABMT in its essence is an implicit learning paradigm that could benefit from longer and multiple training sessions delivered in more comfortable settings (Abend et al., 2013). Systematic delivery of ABMT in-garrison before deployment could better consolidate the effects observed in the current study of acute ABMT delivery. Such systematic effects could be then boosted using frontline delivery protocols similar to the one described here. Double-blinded randomized controlled trials are needed to test this hypothesis. Fourth, due to the unique circumstances under which this study was conducted, we were unable to measure pre and post attention bias and had to focus on ABMT delivery and clinical symptoms. As a result, our study could not shed light on mechanistic questions by showing how change in bias mediate change in symptoms. Further research is needed in order to elucidate those mechanisms.

In conclusion, the current study provides preliminary evidence to the possibility of selective prevention of stress-related symptoms in soldiers prior to combat deployment. Follow-up research in a context that would present greater traumatic exposure then in our study is needed. Importantly, there are significant differences between prevention-based trials for PTSD as opposed to other emotional problems. This is because it is practically impossible to identify specific individuals within larger, at-risk populations, as the targets of the preventative intervention for PTSD. Specifically, in combat-related PTSD, the targeted soldier population has not yet been exposed to trauma prior to deployment, with traumatic exposure being a mandatory feature of the diagnosis. Thus, an analysis of preventative efficacy in the case of PTSD must focus on the interaction between the intervention and levels of traumatic exposure (Guyker et al., 2013). The current report shows that ABMT has the potential to moderate this specific association in combat-deployed soldiers. It further indicates that adaptive attentional deployment may closely correspond with the specific nature of environmental demands. Specifically, the ABMT intervention applied here was based on the assumption that in a situation where it is conducive and adaptive for attention to be employed toward threat and that threat is pertinent, probing attention to threat-related material will enhance this adaptability because it is conducive to environmental demands. The viability of this demand-compatibility assumption of attentional deployment should be tested and validated in future research.

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