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Heightened Attentional Capture by Threat in Veterans With PTSD

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Although an attentional bias for threat-relevant cues has been theorized in posttraumatic stress disorder (PTSD), to date empirical demonstration of this phenomenon has been at best inconsistent. Furthermore, the nature of this bias in PTSD has not been clearly delineated. In the present study, veterans with PTSD ($n = 20$), trauma-exposed veterans without PTSD ($n = 16$), and healthy nonveteran controls ($n = 22$) completed an emotional attentional blink task that measures the extent to which emotional stimuli capture and hold attention. Participants searched for a target embedded within a series of rapidly presented images. Critically, a combat-related, disgust, positive, or neutral distracter image appeared 200 ms, 400 ms, 600 ms, or 800 ms before the target. Impaired target detection was observed among veterans with PTSD relative to both veterans without PTSD and healthy nonveteran controls after only combat-related threat distracters when presented 200 ms, 400 ms, or 600 ms before the target, indicating increased attentional capture by cues of war and difficulty disengaging from such cues for an extended period. Veterans without PTSD and healthy nonveteran controls did not significantly differ from each other in target detection accuracy after combat-related threat distracters. These data support the presence of an attentional bias toward combat related stimuli in PTSD that should be a focus of treatment efforts.

Keywords: PTSD, threat, attention, disengagement

For several years, the Unites States (US) military has been engaged in combat in Iraq and Afghanistan, and there is growing concern that posttraumatic stress disorder (PTSD) awaits many US military personnel (Smith et al., 2008). PTSD is a psychiatric condition marked by a failure to recover from initial symptomatic reactions to traumatic event exposure. Symptoms of PTSD include reexperiencing the traumatic event (e.g., flashbacks, nightmares), avoidance and numbing (e.g., restriction of affect, avoidance of traumatic event cues), and hyperarousal (e.g., exaggerated startle response, difficulty sleeping; American Psychiatric Association, 2000). It has been proposed that the failure to recover from initial symptomatic reactions to trauma in PTSD may be explained, in part, by a selective attentional bias that automatically favors trauma-relevant cues (Ehlers & Clark, 2000). Although the mechanisms underlying this bias remain unclear, heightened fear responding to a traumatic event may prime threatening representations to become readily activated by trauma-relevant cues (McNally, 2006). Preferential attentional processing of threat may then reinforce preoccupation with the trauma and contribute to the repeated accessing of trauma-related memories observed among veterans with PTSD.

The majority of evidence of an attentional bias for threat among veterans with PTSD comes from studies using the emotional Stroop color-naming task (Stroop, 1935). Slower response latencies in color naming threat words compared with color-naming neutral words is thought to arise from difficulty inhibiting the strong associative connections of threat words and is often interpreted as reflecting an attention bias for threat (Williams, Mathews, & MacLeod, 1996). Research using the emotional Stroop task has shown that veterans with PTSD take longer to name the color in which trauma-related words are printed than do nonanxious controls (McNally, English, & Lipke, 1993), suggesting preferential attentional processing of threatening information. However, a recent meta-analysis of emotional Stroop studies found that PTSD patients *and* trauma-exposed control participants do not differ from each other in response latencies for color naming PTSD-relevant words (Cisler et al., 2011). Furthermore, PTSD-relevant words *and* generally threatening words impaired performance to a similar degree relative to neutral words among those with PTSD. Although these findings cast doubt on the view that an attentional bias for combat-related threat is *uniquely* characteristic of veterans with PTSD, methodological limitations of the emotional Stroop task prevent definitive inferences. Indeed, some authors have questioned whether the emotional Stroop captures individual differences in selective attention as opposed to other generic sources of slowing after exposure to negative emotional material (Algom, Chajut, & Lev, 2004).

The dot probe task is also often-used to examine selective attention to threat in PTSD (Bryant & Harvey, 1997; Fani et al., 2012). A facilitated response to probes that appear at the same location of threat information in comparison with responses to probes at the opposite location of threat information is interpreted as vigilance for threat in PTSD. However, research has shown that the findings of studies using the dot probe paradigm can be ambiguous evidence for the vigilance to threat hypothesis in PTSD (Koster, Crombez, Verschuere, & De Houwer, 2004). That is,

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findings from such studies can also be interpreted as a difficulty to disengage from threat. Although recent research has begun to use eye-tracking technology (Beevers, Lee, Wells, Ellis, & Telch, 2011; Felmingham, Rennie, Manor, & Bryant, 2011) and other emotion-attention paradigms in PTSD or individuals exposed to trauma (Pineles, Shipherd, Welch, & Yovel, 2007; Bar-Haim et al., 2010), demonstration of a consistent and unique attentional bias involving facilitated detection of threat stimuli in PTSD has remained elusive.

The emotional attentional blink paradigm (a.k.a, the "emotional blink of attention"; Most, Chun, Widders, & Zald, 2005), may provide a particularly useful tool for probing attentional biases in PTSD. Indeed, recent research has shown that the task may have utility in differentiating patients with other anxiety disorders from controls in the extent to which emotional distractors capture attention (Olatunji, Ciesielski, Armstrong, & Zald, 2011; Olatunji, Ciesielski, & Zald, 2011). On each trial of this task, participants view a rapid serial visual presentation (RSVP) of stimuli and attempt to detect a rotated target image, which occurs at varying intervals (e.g., 200 ms, Lag 2 vs. 800 ms, Lag 8) downstream from an emotional distracter. The attentional blink paradigm taps an exogenous orienting response through which a stimulus automatically captures attention (Chun & Potter, 1995). This capture phenomenon is so great that no other stimuli are consciously processed for a period of time after capture. Whereas probe-detection, emotional Stroop, and visual search tasks attempt to gauge similar effects through delayed reaction times to competing stimuli, the attentional blink effect can be measured in terms of the mere awareness of other stimuli. Awareness of a stimulus is of course intimately linked to attention (e.g., Most, Scholl, Clifford, & Simons, 2005) and can be objectively measured by gauging one's ability to detect a target in the RSVP. Further, the varying "lags" between the distracter image and the rotated target image in the RSVP allow insight into the time course of attentional effects. At the shortest interval after the distracter (200 ms, Lag 2), impaired target detection reflects the involuntary capture of attention, whereas in subsequent time intervals (400 ms, Lag 4 through 800 ms, Lag, 8), the persistence of impaired target detection increasingly reflects difficulty recovering from attentional capture (i.e., disengagement).

Given the importance of attentional biases to current theories of PTSD, we used the emotional attentional blink paradigm to more clearly delineate the nature of attentional biases for threat among veterans with PTSD. Although a verbal attentional blink paradigm has been used with an analogue sample of students endorsing PTSD-like symptoms (Amir et al., 2009), the findings were inconclusive. An image-based version of the attentional blink paradigm may yield more robust findings from which more definitive inferences can be made. It was predicted in the present study that relative to combat-exposed veterans without PTSD and nonveteran healthy controls, veterans with PTSD would show enhanced attentional capture to combat images as reflected in a significant decrement in target detection following combat images, but not other distracters, at the shortest delay. Consistent with reported deficits in attentional disengagement in PTSD (Pineles et al., 2007), it was also predicted that veterans with PTSD would continue to be less accurate than both control groups after exposure to combat images at longer delays.

Method

Participants

Participants consisted of 20 veterans who met diagnostic criteria for PTSD, 16 veterans endorsing criterion A1 of the *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition (*DSM–IV*) diagnosis for PTSD (the person has been exposed to a traumatic event in which the person experienced, witnessed, or was confronted with an event or events that involved actual or threatened death or serious injury, or a threat to the physical integrity of self or others) that did not meet diagnostic criteria for PTSD, and 22 nonveteran controls (NCC) with no current diagnoses.[1] Participants were recruited though community advertisements and referrals from various veteran services. Veteran participants were postdeployment, and those meeting criteria did so because of a combat-related event (as opposed to car accident, etc.). Diagnoses were based upon the *Mini International Neuropsychiatric Interview* (MINI; Sheehan et al., 1998). The MINI is a structured clinical interview used to assess 17 Axis I disorders. The MINI was administered by trained master- and doctoral-level clinicians who were supervised by a trained clinical psychologist. Exclusionary criteria for all participants included a diagnosis of bipolar disorder, intellectual disability, psychosis, ADHD, developmental disorders, mental retardation, or current or past neurological diseases, and traumatic brain injury. Consistent with known patterns of PTSD comorbidity (e.g., Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995), the majority of veterans with PTSD met diagnostic criteria for at least one additional Axis I diagnosis (81%), including 71% with another anxiety disorder and 24% with a mood disorder. Common comorbid anxiety disorders include generalized anxiety disorder and panic disorder and agoraphobia. Common comorbid mood disorders include major depressive disorder and dysthymia.

Symptom Assessment

The Post-Traumatic Stress Disorder Checklist. The Post-Traumatic Stress Disorder Checklist, Civilian Version (PCL-C; Weathers, Litz, Herman, Huska, & Keane, 1993) is a 17-item measure of PTSD symptoms severity over the past month. The PCL-C had excellent internal consistency in the present study ($\alpha = .97$).

The State–Trait Anxiety Inventory. The State–Trait Anxiety Inventory, Trait (STAI-T; Spielberger et al., 1983) is a 20-item

[1] A subset of veterans with ($n = 11$) and without ($n = 9$) PTSD in the present study completed the Combat Exposure Scale (CES; Keane, Fairbank, Caddell, Zimering, Taylor, & Mora, 1989), a seven-item self-report measure of wartime stressors experienced by combatants. Items are rated on a five-point frequency (1 = *no* or *never* to 5 = *more than 50 times*), five-point duration (1 = *never* to 5 = *more than 6 months*), four-point frequency (1 = *no* to 4 = *more than 12 times*) or four-point degree of loss (1 = *no one* to 4 = *more than 50%*) scale. Respondents are asked to respond based on their exposure to various combat situations, such as firing rounds at the enemy and being on dangerous duty. The total CES score (ranging from 0 to 41) is calculated by using a sum of weighted scores, which can be classified into one of five categories of combat exposure ranging from *light* to *heavy*. Administration of the CES revealed no significant differences in trauma exposure between Veterans with (mean = 25.63, $SD = 9.42$) and without (mean = 20.44, $SD = 8.38$) PTSD, $t(18) = 1.28$, $p = .21$.

measure of one's proneness toward experiencing anxiety and distress (trait anxiety). The STAI-T had good internal consistency in the present study ($\alpha = .96$).

The Beck Depression Inventory. The Beck Depression Inventory (BDI; Beck, Steer, & Garbin, 1988) is a 21-item measure of depressive symptoms. The BDI had good internal consistency in the present study ($\alpha = .95$).

Rapid Serial Visual Presentation (RSVP) Task Materials

"Filler" images (not target or distracter) included 256 upright landscapes/architectural images. Target images consisted of 96 landscape/architectural photos presented in two rotations: 90° to the left and 90° to the right. Distracter images consisted of four categories, combat-related threat (e.g., soldiers firing guns), disgust (e.g., feces), pleasant (e.g., baby animals), and neutral (e.g., household objects), with 17 images per category, presented twice. Disgust, pleasant, and neutral images were partially drawn from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999) and were supplemented with similar images found from publicly available sources. War images were mainly obtained from publicly available sources.[2] Stimuli were presented through E-Prime software (Psychology Software Tools, Inc.) run on a Dell computer.

Procedure

All participants completed written informed consent approved by the Vanderbilt Institutional Review Board. Participants completed the diagnostic interview, and were then seated at a computer where they completed the symptom measures, followed by the emotional attentional blink task. The RSVP task consisted of a series of 17 images that were presented on the screen for 100 ms in rapid succession (see Figure 1). On 89% of trials, one of these images (the "target") was rotated 90° to the left or the right. The participant's task was to indicate whether or not a rotated image was present (detection), and if so, which direction it was rotated (accuracy). Here, chance performance on the task would be 50%. Although 100 ms would be considered supraliminal, participants did typically report "seeing" the critical distractor. Consistent with prior research (e.g., Olatunji et al., 2011), analyses for accuracy, rather than detection, are presented as they reflect more precise performance on the RSVP. A "distracter" image was placed at varying intervals before the target. Distracter images appeared in the stream at positions 2, 4, 6, or 8, with the target appearing downstream at varying "lags" [200 ms (lag 2), 400 ms (lag 4), 600 ms (lag 6), or 800 ms (lag 8)]. Position and lag were equally distributed for each distracter category. Participants completed six blocks with 36 trials per block. Each distracter type was presented 54 times with six trials per distracter type containing no target (216 total target trials, 24 total no target trials). Before the task, participants performed 16 practice trials with four of the 16 trials containing no rotated target image, six trials with the target image rotated to the right, and six trials with the target image rotated to the left. Distracters were neutral for the practice trials.

Results

Participant Characteristics

Participants were well-matched on several demographic characteristics with no significant differences between the three groups on gender, age, ethnicity, and marital status (see Table 1). The three groups did significantly differ in income [$F(2, 55) = 3.73$, $p < .05$, partial $\eta^2 = .12$] and years of education [$F(2, 55) = 19.54$, $p < .001$, partial $\eta^2 = .42$]. As expected, healthy nonveteran controls had significantly higher incomes than veterans with PTSD ($p < .02$). However, income level for veterans without PTSD did not significantly differ from healthy nonveteran controls and veterans with PTSD. Similarly, healthy nonveteran controls were more educated than veterans with and without PTSD ($ps < .001$). However, years of education did not significantly differ between veterans with PTSD and those without PTSD. Table 2 shows that, as expected, veterans with PTSD reported significantly more symptoms of PTSD than veterans without PTSD. Table 2 also shows that veterans with PTSD reported significantly more trait anxiety and depression than veterans without PTSD and healthy nonveteran controls. However, veterans without PTSD and healthy nonveteran controls did not significantly differ from each other in trait anxiety and depression.

RSVP Task Accuracy

Means and standard deviations of percent accuracy on the RSVP by Group, Lag, and Distracter are presented in Table 3. A 3 (Group; Veterans with PTSD, Veterans without PTSD, nonveteran NCC) × 4 (Lag; 2, 4, 6, 8) × 4 (Distracter; combat-related threat, disgust, happy, neutral) mixed model Analysis of Variance (ANOVA) on percent accuracy revealed a significant main effect of Group [$F(1, 2) = 3.20$, $p < .05$, partial $\eta^2 = .10$], reflecting lower accuracy among veterans with PTSD compared with nonveteran healthy controls but not veterans without PTSD, Lag [$F(3, 165) = 57.84$, $p < .001$, partial $\eta^2 = .51$], reflecting higher accuracy with increase in Lag, and Distracter [$F(3, 165) = 33.46$, $p < .001$, partial $\eta^2 = .38$], reflecting differential performance across emotional stimulus categories. These main effects were qualified by significant Group × Distracter [$F(6, 165) = 5.79$, $p < .001$, partial $\eta^2 = .17$] and Lag × Distracter [$F(9, 495) = 21.28$,

[2] Healthy nonveteran controls from the present study ($n = 20$) rated each Combat (valence = −13.25, $SD = 9.78$; arousal = 29.88, $SD = 20.76$), Disgust (valence = −20.12, $SD = 9.95$; arousal = 37.01, $SD = 21.56$), Positive (valence = 17.87, $SD = 8.56$; arousal = 31.67, $SD = 14.43$), and Neutral (valence = 2.04, $SD = 1.32$; arousal = 4.01, $SD = 6.365$) image for valence (−50 = extremely negative, +50 = extremely positive, 0 = being no positive or negative valence/neutral) and arousal (0 = none to 100 = extremely/most imaginable) after the experiment. A significant main effect of valence was found [$F(3, 57) = 69.19$, $p < .001$] such that combat images were rated more negatively than positive and neutral images ($ps < .001$). Disgust images were also rated as significantly more negative than positive and neutral images ($ps < .001$). However, the valence of combat and disgust images did not significantly differ from each other ($p > .05$). Positive images were also rated more positive than all the other images ($ps < .001$). A significant main effect of arousal was also found [$F(3, 57) = 16.83$, $p < .001$] such that combat, disgust, and positive images were rated significantly more arousing than neutral images ($ps < .001$). However, arousal ratings for combat, disgust, and positive images did not significantly differ from each other ($p > .05$).

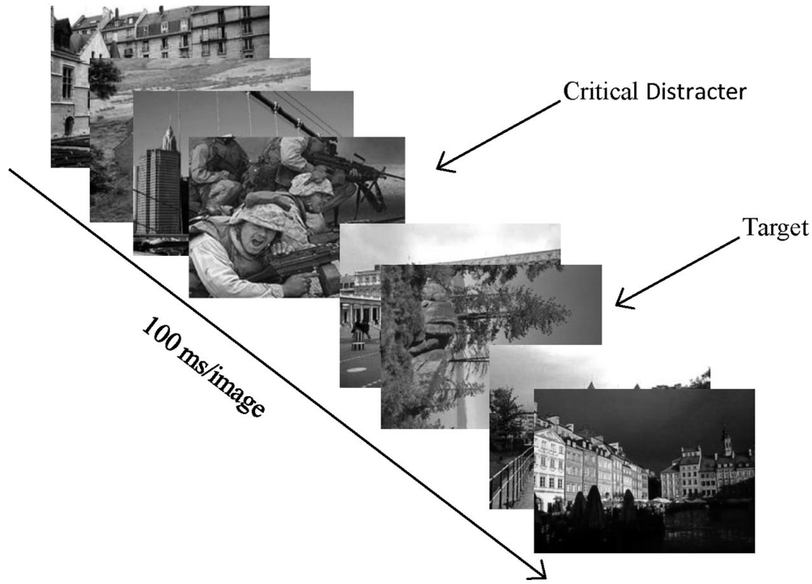

Figure 1. The trial structure for the emotional attentional-blink paradigm (Lag 2 depicted).

$p < .001$, partial $\eta^2 = .28$] interactions. The predicted Group × Lag × Distracter interaction was also significant [$F(18, 495) = 1.76$, $p < .03$, partial $\eta^2 = .06$].

To examine the Group × Lag × Distracter interaction, a 3 (Group) × 4 (Lag) mixed model ANOVA was conducted on accuracy for each Distracter type. This analysis revealed a significant main effect of Group [$F(2, 55) = 9.25$, $p < .001$, partial $\eta^2 = .25$] and Lag [$F(3, 165) = 21.46$, $p < .001$, partial $\eta^2 = .28$] that was qualified by a significant Group × Lag interaction [$F(6, 165) = 2.88$, $p < .02$, partial $\eta^2 = .10$] for combat-related threat distracters only. As depicted in Figure 2, multivariate examination of the significant Group × Lag interaction for combat-related threat distracters revealed significant group differences in accuracy for detection at Lag 2 [$F(2, 55) = 8.14$, $p < .001$, partial $\eta^2 = .23$], Lag 4 [F(2. 55 = 7.53, $p < .001$, partial $\eta^2 = .22$], and Lag 6 [$F(2, 55) = 7.20$, $p < .002$, partial $\eta^2 = .21$], but not Lag 8 [$F(2, 55) = 1.79$, $p = .179$, partial $\eta^2 = .06$].[3] At Lag 2, Lag 4, and Lag 6, veterans with PTSD were less accurate in detecting the target after combat-related threat distracters than veterans without PTSD ($ps < .02$) and nonveteran healthy controls ($ps < .01$). By contrast, veterans without PTSD and nonveteran healthy controls did not significantly differ in this regard ($ps > .25$). No significant group differences were found at Lag 8, consistent with past studies indicating that emotion-induced attentional blinks are typically resolved by 800 ms (Most, Chun, Widders, & Zald, 2005). Critically, the Group effects were specific to combat distracters, as there were no Group effects or Group × Lag interactions for disgust, neutral, or happy distracters (all $p > .05$).[4] That is, to the extent that these stimuli caused an attentional blink, the blink was similar across groups. Indeed, a large attentional blink was seen for all subjects after disgust distracters (reflected in a robust main effect of Lag [$F(3, 165) = 92.81$, $p < .001$, partial $\eta^2 = .63$], but the magnitude of the response was not influenced by either diagnosis or history of trauma exposure. Thus, the enhanced attentional blink displayed by PTSD patients was unique to the combat distracters.

Table 1
Demographic Information by Diagnostic Group

	Veterans + PTSD	Veterans − PTSD	Nonveteran NCC
n	20	16	22
% male	90	94	91
Age (*SD*)	33.55 (6.78)	34.69 (7.68)	32.86 (6.35)
% Caucasian	85	88	77
% Married	40	31	50
Years of education	14.10	13.62	17.04
Average income	\$34,500	\$48,750	\$55,700

Note. + PTSD = with Post-Traumatic Stress Disorder; − PTSD = Without Post-Traumatic Stress Disorder; NCC = Nonclinical control.

[3] This pattern of findings was unchanged when partialling out income, education, anxiety, and depression. In fact the nonsignificant Group × Lag interaction for combat-related threat distracters at Lag 8 became significant when partialling out anxiety (STAI-T) and depression (BDI) scores [$F(2, 53) = 5.16$, $p < .01$, partial $\eta^2 = .16$]. Like Lag 2, Lag 4, and Lag 6, veterans with PTSD were less accurate in detecting the target after combat-related threat distracters at Lag 8 than veterans without PTSD ($p < .01$) and nonveteran healthy controls ($p < .02$) when partialling out anxiety and depression. By contrast, veterans without PTSD and nonveteran healthy controls did not significantly differ in this regard ($p = .52$) when partialling out anxiety and depression.

[4] The mixed model ANOVA on percent accuracy was also conducted with just disgust and combat-related threat trials. The predicted Group × Lag × Emotion interaction was still significant [$F(6, 165) = 2.81$, $p < .02$, partial $\eta^2 = .09$], suggesting that the observed group differences are specific to combat-related threat trials as opposed to a negativity bias per se. The mixed model ANOVA on percent accuracy was also conducted without the combat-related threat trials. The predicted Group × Lag × Emotion interaction was no longer significant [$F(12, 330) = 1.33$, $p = .199$, partial $\eta^2 = .05$], suggesting that the observed group differences are accounted for by the combat-related threat trials.

Table 2
Means and Standard Deviation by Group on Symptom Measures

Symptoms	Veterans + PTSD *M* (*SD*)	Veterans – PTSD *M* (*SD*)	Nonveteran NCC *M* (*SD*)	*F*	Partial η^2
PCL-C	60.90 (13.28)[a]	25.18 (6.12)[b]	—	98.26	.74
STAI-T	53.60 (10.98)[a]	33.06 (8.29)[b]	31.54 (8.65)[b]	33.86	.55
BDI	23.35 (10.46)[a]	4.25 (4.79)[b]	3.13 (5.32)[b]	46.58	.63

Note. + PTSD = with Post-Traumatic Stress Disorder; − PTSD = Without Post-Traumatic Stress Disorder; NCC = Nonclinical control; — = did not complete; PCL-C = Post-Traumatic Stress Disorder Checklist-Civilian Version; STAI-T = State Trait Anxiety Inventory – Trait Subscale; BDI = Beck Depression Inventory. All *F* values significant at $p < .001$; values with difference subscripts are significantly different from each other.

Discussion

This investigation examined the extent to which threat-relevant cues uniquely capture attention among veterans with PTSD on an emotional attentional blink RSVP task. The present findings showed that although group differences in detection accuracy as a function of lag did not significantly differ when disgust, happy, and neutral distracters were presented, significant group differences in detection accuracy as a function of lag did emerge when combat images were used as distracters. Examination of this pattern of findings revealed that at Lag 2, Lag 4, and Lag 6, but not Lag 8, veterans with PTSD were less accurate in detecting the target after combat-related threat distracters than Veterans without PTSD and nonveteran healthy controls. Importantly, however, combat-exposed veterans without PTSD and nonveteran healthy controls did not significantly differ in detection accuracy when combat images were used as distracters. These findings suggest that heightened attentional capture by trauma-relevant threat is uniquely characteristic of veterans with PTSD.

The present findings are consistent with cognitive theories that implicate preferential processing of trauma cues in PTSD (Brewin & Holmes, 2003; Ehlers & Clark, 2000). Moreover, they provide insight into the nature of the attentional bias in PTSD. That veterans with PTSD showed impairments at the earliest lag (Lag 2) indicates a proneness to attentional capture by trauma relevant cues. This preferential processing of trauma-relevant cues among veterans with PTSD may reflect both a heightened vigilance for trauma-relevant cues as well as an excessive orienting response when such stimuli are perceived. The phenomena of attentional capture to emotionally valenced stimuli is thought to distinctly reflect automatic, bottom-up processing as opposed to strategic top-down stages of information processing (Carretié, Hinojosa, Martin-Loeches, Mercado, & Tapia, 2004). Such automatic direction of attention to exogenous stimuli typically reflects processing that is capacity free and occurs without intent, control, or awareness (Shiffrin & Schneider, 1977). Importantly, the veterans with PTSD did not show a generalized proneness to attentional capture, as they showed similar levels of performance to the other groups when exposed to neutral, positive, and disgust-related stimuli. Thus, they do not appear to have a generalized heightened vigilance for or orienting to emotionally valenced stimuli, or even negatively valenced stimuli. Rather, they appear to show preferential processing of trauma-relevant stimuli.

In addition to the heightened attentional capture demonstrated here, recent research has suggested that PTSD is associated with a reduced capacity for top-down attentional control of bottom-up, stimulus-driven effects (Johnsen, Kanagaratnam, & Asbjørnsen, 2011). Such a top-down regulatory ability (Posner & Rothbart, 2000) is necessary to counter the bottom-up influence of emotionally salient stimuli that compete for attention (Eysenck, Derakshan, Santos, & Calvo, 2007), and these executive control deficits have been postulated to underlie the experience of intrusive emotional memories (Levy & Anderson, 2008; Vasterling, Brailey, Constans, Sutker, 1998). Such difficulties could lead to problems in attentional disengagement in PTSD, consistent with the work of Pineles and colleagues (2007), who reported evidence of excessive interference caused by threat words in a visual search task with a lexical decision component. Preexisting deficits in attention control among veterans with PTSD, relative to veterans without PTSD, may partially explain the unique attentional capture by combat related images observed in the present study. Subsequent to combat-related trauma, deficits in attention control may make it difficult for veterans that go on to develop PTSD to efficiently regulate the recollection and emotional costs of the trauma. This view is consistent with prior research showing that individuals with higher levels of attention control are better able to attenuate distress associated with trauma cues compared to those with low levels of attention control (Bardeen & Read, 2010). However, these effects are likely to be bidirectional. Indeed, the findings of Bardeen and Read also suggest that heightened trauma-related distress negatively affects one's ability to efficiently exercise attention control. Recent research has also shown that heightened emotional responding among those with PTSD, relative to those exposed to trauma, may lead to heightened interference in the recruitment of brain regions implicated in top-down attentional control (Blair et al., 2012). These findings suggest that heightened emotional responding to trauma cues among veterans with PTSD, relative to those without PTSD, may lead to difficulties in attentional control and the subsequent interference of trauma cues.

The present data provide some support for an inability to disengage orienting to threat-relevant cues among veterans with PTSD, as these individuals continued to show impairment in target detection for up to 600 ms after exposure to the trauma-relevant stimuli. As one moves further out in time from the attention capturing stimulus, top-down strategic processing should allow a refocusing of attention (Dux & Marois, 2009). The prolonged blink displayed by veterans with PTSD suggests the presence of both heightened automatic processing of threat *and* deficient strategic control of attention. Two caveats are warranted, however, regarding the issue of disengagement. First, the absence of any group differences at Lag 8 suggests that strategic processing abil-

Table 3
Rapid Serial Visual Presentation Task Means and Standard Deviations of Accuracy Percentage by Emotion, Lag, and Group

	Veterans with PTSD				Veterans without PTSD				Non-veteran controls			
Lag	Combat *M (SD)*	Disgust *M (SD)*	Happy *M (SD)*	Neutral *M (SD)*	Combat *M (SD)*	Disgust *M (SD)*	Happy *M (SD)*	Neutral *M (SD)*	Combat *M (SD)*	Disgust *M (SD)*	Happy *M (SD)*	Neutral *M (SD)*
2	56.75 (26.70)	47.62 (17.51)	68.65 (21.07)	76.19 (13.77)	72.92 (17.87)	10.92 (46.88)	77.60 (16.02)	72.40 (12.44)	80.30 (10.14)	51.89 (17.62)	82.95 (16.36)	76.52 (7.56)
4	63.49 (19.98)	73.81 (17.73)	76.59 (16.80)	80.95 (15.17)	81.77 (13.68)	72.40 (13.51)	84.38 (14.23)	85.94 (11.27)	81.44 (14.53)	77.65 (14.86)	83.71 (15.74)	84.47 (9.38)
6	77.78 (15.44)	82.14 (15.20)	76.59 (14.34)	83.33 (12.08)	88.02 (7.43)	86.98 (13.25)	83.85 (8.86)	86.46 (13.90)	89.39 (8.60)	85.98 (14.18)	75.76 (12.84)	87.88 (13.04)
8	78.97 (17.00)	71.03 (17.80)	75.40 (15.25)	85.32 (14.17)	86.98 (9.11)	76.04 (8.54)	83.33 (10.09)	82.81 (10.31)	83.71 (11.06)	79.92 (13.03)	82.20 (12.41)	84.85 (15.35)

ity, even among veterans with PTSD, is relatively intact after 800 msec. This is consistent with prior research showing that attentional capture by emotional stimuli on the attention blink task is no longer evident after 800 ms in the vast majority of subjects (Most, Chun, et al., 2005; Smith, Most, Newsome, & Zald, 2006). Second, although strategic processes become more prominent the further one moves in time from an attention capturing stimulus, because the veterans with PTSD show such a large attentional capture (as evidenced by their poor performance at lag 2), it is not possible to specifically determine whether their poor performance at the later lags reflects a unique problem with disengagement because a greater orienting response could potentially cause these effects in the absence of a specific problem in disengagement. Indeed, the rate of recovery (as reflected in the increased target accuracy across lags) suggests that the PTSD patients show a normal rate of recovery but have such a large orienting response that it takes several hundred ms to recover. Nevertheless, at a minimum, the veterans with PTSD appear unable to overcome their heightened orienting response, leading to deficits continuing after the trauma-related stimulus has past.

One factor that may contribute to the robustness of the present effects is the use of salient combat-related pictures for stimuli, in contrast to many studies that have relied on verbal stimuli or stimuli that are not specific to the trauma. For instance, in a study using a verbal attentional blink paradigm in an analogue sample of college undergraduates who endorsed PTSD-like symptoms, Amir et al. (2009) observed no effects of threat versus neutral words appearing at T1 on detection of neutral target words appearing at T2. The authors only showed evidence of a difference between these subjects and subjects without significant PTSD-like symptoms when they applied a complex dual-task design in which participants were asked to perform a categorization of whether T1 was a threat or neutral word, and the effect appeared largely driven by differences in the neutral condition, as accuracy after threat-related words was quite similar across groups. Although the significant methodological differences between studies limit firm conclusions, we speculate that the stimuli must be both relevant to the trauma experience and emotionally salient to reveal heightened attentional capture in PTSD patients. By using probes capable of detecting disease-specific attentional biases, it may become possible to more directly test the relationship between these biases and the development and maintenance of PTSD. Although attentional biases have been theorized to play a role in the transition from acute stress reactions to persistent PTSD-symptoms (Ehlers & Clark, 2000), longitudinal studies directly testing causal relations have been limited, in part as a result of the lack of robust paradigms for assessing such biases.

These novel findings with the attentional blink paradigm may advance knowledge on information processing biases in PTSD. Models often attribute the attentional blink effect, a deficit in recognizing the second of two temporally proximal targets within a rapid stream, to central processes such as bottlenecks gating access to working memory (e.g., Chun & Potter, 1995) or errors in target retrieval from memory (Shapiro, Raymond, & Arnell, 1994). However, recent research examining the extent to which emotional stimuli impair awareness of subsequent targets ('emotion-induced blindness') suggests that emotional cues have a dual impact on perception by grabbing spatial attention and inhibiting competing episodic representations at their location (Most & Wang, 2011).

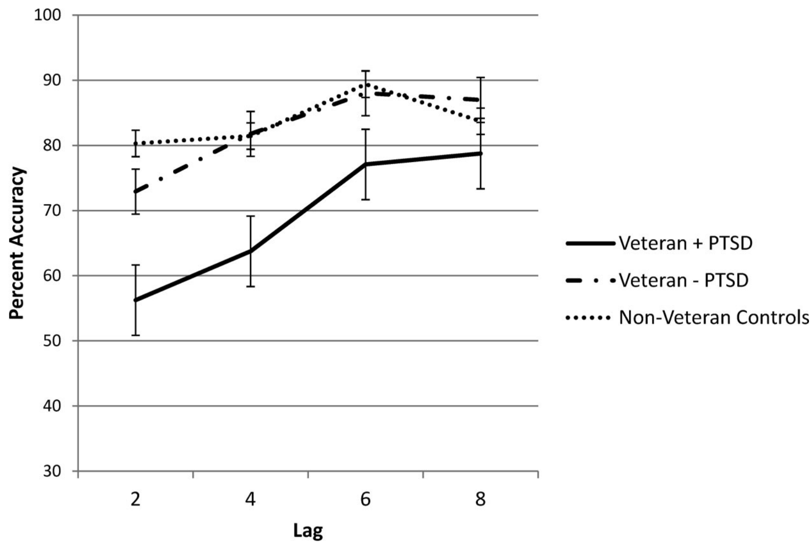

Figure 2. Percent detection accuracy by group and lag for combat-related threat distracters. Bars represent standard error.

The present findings suggest that this process is relatively intact among veterans with PTSD. Indeed, disgust stimuli caused an attentional blink that was similar for veterans with PTSD, veterans without PTSD, and nonveteran controls. Unlike veterans without PTSD and nonveteran controls, however, the present study suggests that spontaneous prioritization of combat stimuli among veterans with PTSD inhibits formation of other representations. One important implication of these findings is that spontaneous prioritization of combat-related cues in the environment among veterans with PTSD may lead to inhibition of spatiotemporally competing safety information, and this may be one mechanism by which symptoms are maintained (Grieger, Fullerton, & Ursano, 2004).

Although the present study suggests that the attentional blink paradigm with visual images may have great utility in delineating the nature and components of attentional biases for threat in PTSD, the present findings must be considered within the context of the study limitations. For example, the sample size for the PTSD and non-PTSD groups was relatively small. Furthermore, the PTSD group was limited to those with only combat-related trauma. Although data on a subsample of participants suggest that trauma exposure was statistically equivalent for veterans with and without PTSD, the absence of such data for the full sample is also a limitation of the present study. Related to this issue is that the present study may not be sufficiently poised to rule out the possibility that familiarity effects primarily account for the heightened attentional capture among veterans with PTSD. Although a subsample of veterans with PTSD and those without PTSD did not statistically differ in trauma exposure, the difference were nonetheless sizable (with veterans with PTSD reporting more trauma exposure than those without PTSD), which further indicates that the sample size of the study was limited. Thus it does remain somewhat unclear whether the attention effects reflect differential exposure to experiences related to the stimulus material as opposed to PTSD per se.

Despite the study limitations, the present findings may have treatment implications as trauma-exposed individuals encounter a continuous string of stimuli in daily life that compete for attentional resources. Preferential orienting to trauma cues may interfere with the processing of subsequent information in the environment for a relatively prolonged period among veterans with PTSD. Preferential processing of trauma cues may contribute to priming of negative emotional information about the traumatic even (Michael, Elhers, & Halligan, 2005). Accordingly, the implementation of interventions that directly modify both vigilance for and difficulty disengaging from trauma-relevant cues among veterans with PTSD may offer symptom relief by decreasing the speed and strength with which representations of war related trauma become activated. Attention bias modification treatment appears to show some promise as a novel treatment for anxiety-related disorders, particularly social anxiety disorder and generalized anxiety disorders (Hakamata et al., 2010). Such data highlight the potential therapeutic benefits of extending attention bias modification interventions to the treatment of PTSD, because reducing attentional bias for threat in this disorder may result in a corresponding reduction of symptoms.

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