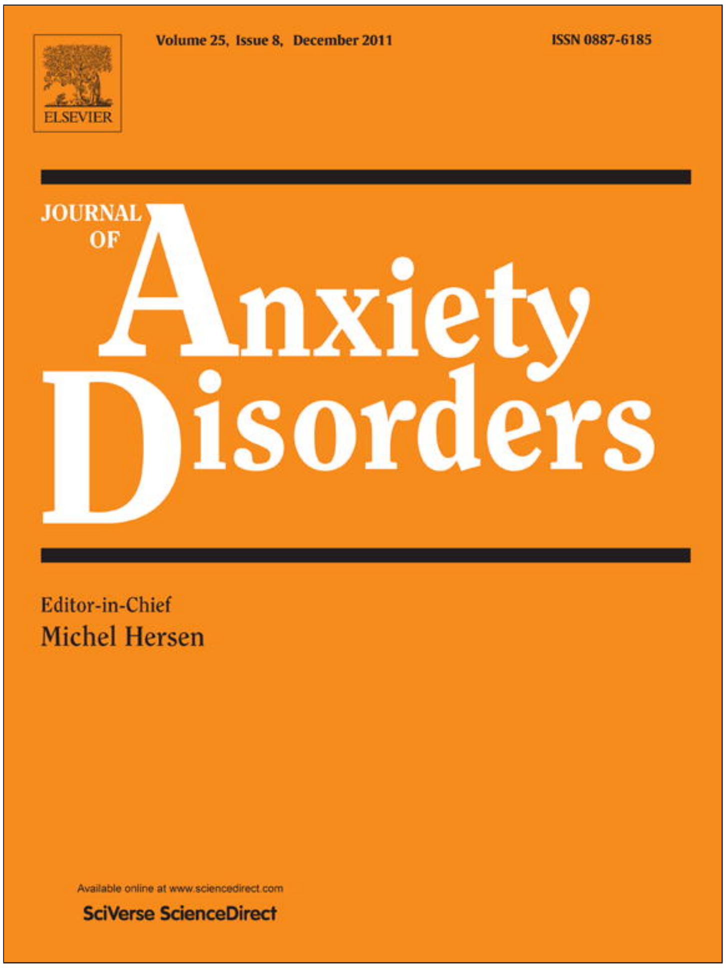
Volume 25, Issue 8, December 2011
ISSN 0887-6185
ELSEVIER
JOURNAL OF
Anxiety Disorders
Editor-in-Chief
Michel Hersen
Available online at www.sciencedirect.com
SciVerse ScienceDirect

Journal of Anxiety Disorders 25 (2011) 1008–1018

Contents lists available at ScienceDirect

Journal of Anxiety Disorders

Attentional control as a moderator of the relationship between posttraumatic stress symptoms and attentional threat bias

Joseph R. Bardeen*, Holly K. Orcutt

Department of Psychology, Northern Illinois University, DeKalb, IL 60115, United States

ARTICLE INFO

Article history:
Received 23 December 2010
Received in revised form 23 June 2011
Accepted 23 June 2011

Keywords:
Executive attention
Attentional control
Attentional bias
Posttraumatic stress disorder
Trauma

ABSTRACT

Attentional threat bias (ATB) has been suggested as one factor leading to maintenance and exacerbation of posttraumatic stress symptoms (PTSS). In the present study, attentional processes (i.e., facilitated engagement, difficulty disengaging) underlying the association between ATB and PTSS were examined. Additionally, attentional control (AC) was examined as a moderator of this relationship. Participants ($N = 97$) completed a dot-probe task with two levels of stimulus-onset asynchrony (SOA: 150 and 500 ms). Higher PTSS were associated with ATB when SOA was longer (i.e., 500 ms), suggesting difficulty disengaging from threat stimuli. AC moderated the relationship between PTSS and ATB when SOA was shorter (i.e., 150 ms), with participants high in PTSS and high in AC having disengaged and shifted attention from threat stimuli using top-down AC when the emotional valence of threat stimuli was less salient (i.e., shorter presentation duration). Findings implicate AC as a buffering mechanism against prolonged attentional engagement with threat-related stimuli among those with high PTSS. Current PTSD interventions may benefit from incorporating attention-based components.

1. Introduction

Hypervigilance toward threatening information, a symptom of posttraumatic stress disorder (PTSD; Diagnostic and Statistical Manual for Psychiatric Disorders-Fourth Edition-Text Revision [DSM-IV-TR]; American Psychiatric Association [APA], 2000), has been implicated as one factor leading to the maintenance and exacerbation of PTSD symptoms (e.g., intrusive thoughts, flashbacks, physiological reactivity, avoidance behaviors, heightened arousal; Constans, 2005; Elzinga & Bremner, 2002). Therefore, among trauma and PTSD researchers, there has been an emphasis on understanding the attentional processing of threat- and trauma-related information among those with PTSD, with the idea that facilitated threat detection (i.e., hypervigilance) is synonymous with PTSD-related attentional threat biases.

Consistent with this conceptualization, a plethora of published journal articles has reported that individuals with PTSD exhibit a bias for attending to trauma-specific stimuli (e.g., Beck, Freeman, Shipherd, Hamblen, & Lackner, 2001; Bryant & Harvey, 1997; McNally, Amir, & Lipke, 1996; McNally, Kaspi, Riemann, & Zeitlin, 1990) and to a lesser degree, general threat stimuli (e.g., Litz et al., 1996). Thus, there has been a general consensus among researchers that an attentional bias to threat information in PTSD is a phenomenon with an overabundance of support in the extant literature (Buckley, Galovski, Blanchard, & Hickling, 2003; Constans, 2005; McNally, 1998). However, a recent examination of peer-reviewed literature and dissertation abstracts has called robustness of this phenomenon into question (Kimble, Frueh, & Marks, 2009).

1.1. Measuring attentional bias

Attentional threat bias is most often conceptualized as being reflexive, automatic, and occurring outside of conscious awareness (Constans, 2005; Yiend, 2010). The modified Stroop task has been used as the primary experimental task to examine attentional biases in PTSD (Constans, 2005). In the traditional Stroop task, participants are asked to name the colors in which words are printed as quickly as possible while ignoring the meaning of the word, a task which becomes more difficult when the color of the ink differs from the meaning of the word (e.g., the word "green" written in red ink). Similarly, in the modified Stroop task, participants are presented with a series of one-word stimuli, each from a specific word category (e.g., trauma, positive, neutral, etc.), and asked to name the color of the word while paying no attention to the word's meaning. Slower responding to specific word stimuli is thought to occur when attention is briefly captured by the potency of word meaning, thus disrupting the processing of color information.

Kimble et al. (2009) conducted a review of peer-reviewed journal articles and dissertation abstracts for studies using the modified Stroop task to examine attentional bias for threat information

* Corresponding author. Tel.: +1 585 738 8307.
E-mail address: jbardeen@niu.edu (J.R. Bardeen).

0887-6185/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.janxdis.2011.06.009

in individuals with PTSD versus individuals without PTSD; both groups had experienced a traumatic event. Contrary to predictions, only 8% of dissertation abstracts and 44% of peer-reviewed journal articles showed slowed responding to threat words among individuals with PTSD. Kimble et al. (2009) suggest that a lack of empirical support for the modified Stroop effect in PTSD may indicate absence of attentional threat bias in PTSD. However, considerable debate exists about the nature of the modified Stroop task, with some suggesting that the task is inappropriate for use in determining information-processing biases (McKenna & Sharma, 2004; Phaf & Kan, 2007; Weierich, Treat, & Hollingworth, 2008).

There are two primary presentation formats of the modified Stroop task: (a) a blocked format which provides a measure of the combined effect of the slow and fast components of attention and (b) a random format which provides a measure of the fast component of attention (McKenna & Sharma, 2004). Contrary to the expectation of automaticity that the traditional Stroop task is founded on, McKenna and Sharma (2004) found no evidence for fast, automatic effects in the modified Stroop task. Furthermore, in a recent meta-analysis of 172 studies that used the modified Stroop task to examine threat-related attentional biases in anxiety, Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, and van IJzandoorn (2007) found evidence of the modified Stroop effect, but only when a blocked presentation format was used. Thus, observed effects are likely the result of slower, higher order regulatory processing; therefore, the modified Stroop task, which does not provide an independent measure of these effects, may not be an appropriate experimental task for examining the processing of threat information in PTSD. The findings of Kimble et al. (2009) are important in advancing research in the area of information processing in PTSD. However, instead of providing contradictory evidence of an association between PTSD and attentional threat bias, Kimble et al.'s (2009) findings suggest that it is necessary to examine attentional threat bias in PTSD using more appropriate experimental tasks.

The dot-probe task is another stimulus-response task used to examine the association between attentional threat bias and anxiety (Salemink, van den Hout, & Kindt, 2007). In the traditional dot-probe task, two stimuli are presented side by side on a computer screen. The stimuli remain on the screen for a specified duration of time, after which a dot appears on the screen, replacing one of the two pictures. The participant presses a button that corresponds to the relative position of the dot on the screen, thus providing the researcher with a snapshot of the participant's attention allocation at that point and time. If the participant has a bias for attending to threat stimuli, s/he should respond faster when the dot appears in the spatial postion previously held by the threat stimuli. Additionally, if the time interval of stimulus presentation varies (e.g., 150 milliseconds [ms], 500 ms), the dot-probe task can provide a temporal examination of attention allocation. However, the majority of research incorporating the dot-probe task has used only one stimulus duration (i.e., 500 ms; Yiend, 2010), a duration of time which likely allows the participant to make multiple shifts in attention.

The only published study related to attentional bias in PTSD to incorporate a dot-probe task found that participants with PTSD showed a bias for attending to mild threat words when compared to participants with subclinical PTSD and participants with low anxiety (Bryant & Harvey, 1997). Interestingly, no attentional bias was observed for strong threat words. These findings may be the consequence of (a) using a modified version of the dot-probe task in which stimulus words were presented simultaneously with a word indicating the direction of the button that the participant was instructed to press (i.e., "left" or "right") and (b) no variation in stimulus-onset asynchrony (SOA; i.e., the duration of time between the initial stimulus presentation and response option). As previously mentioned, the dot-probe task can provide a temporal examination of attention allocation when multiple stimulus presentation intervals are used, and thus, would be helpful in identifying specific attentional processes (i.e., fast [bottom-up], slow [top-down]) that may account for information-processing biases in PTSD.

1.2. Theories of attentional bias: facilitated engagement or difficulty disengaging?

The vigilance-avoidance model of anxiety-associated attentional threat bias presupposes facilitated threat engagement, or orienting of attention toward threat stimuli, which is followed by the subsequent avoidance of such stimuli (Weierich et al., 2008). In contrast, the attention-maintenance model is not based on the premise that there is faster orienting toward threat stimuli; instead, once threat stimuli are attended to, it is more difficult to disengage from such stimuli, especially at higher levels of anxiety (Weierich et al., 2008).

Related theories of attention (i.e., Corbetta & Shulman, 2002; Eysenck, Derakshan, Santos, & Calvo, 2007; Metcalfe & Mischel, 1999) describe attentional threat bias in anxiety in terms of a bottom-up, sensory driven attentional system and a top-down attentional control (AC) system. AC has been described as one's ability to use higher level executive functioning to regulate, or override, automatic emotional responses (Derryberry & Reed, 2002). In Metcalfe and Mischel's (1999) conceptualization, the "hot" system (bottom-up) is specialized for immediate responding and emotional processing, whereas the "cool" system (top-down) is specialized for reflective emotion regulation and control of impulsive tendencies.

The balance between these two attentional systems is thought to be disrupted when high levels of stress/anxiety impair the cool system and potentiate the hot system (Eysenck et al., 2007; Metcalfe & Mischel, 1999). The top-down attentional system, controlled by the central executive, is seen as being responsible for three main functions of AC: (a) the inhibition of dominant, automatic responses, (b) shifting back and forth between multiple task demands, and (c) updating working memory. Research has consistently shown that anxiety impairs two of these three functions: the inhibition of dominant, automatic responses and shifting back and forth between multiple task demands (Graydon & Eysenck, 1989; Lavie, Hirst, de Fockert, & Viding, 2004). Therefore, individuals in a heightened state of anxiety will be less successful at tasks in which the executive attentional mechanisms of inhibition and shifting are needed. Furthermore, when task-irrelevant stimuli increase participant distress, these stimuli will be attended to for a greater length of time as a result of anxiety's detrimental influence on inhibition and switching functions. However, at low levels of stress, the cool system allows for the inhibition of hot system dominant response tendencies (Metcalfe & Mischel, 1999). Additionally, Metcalfe and Mischel (1999) proposed that hot system activity is more likely to trigger cool system activation in individuals with better developed, more complex cool systems, with cool control eventually becoming an almost automatic response to hot system activation. Thus, individuals with high levels of PTSS who report experiencing high levels of anxiety and persistent arousal (i.e., hot system activation) may have greater difficulty disengaging from threat-relevant information due to impairment of the cool system (i.e., AC).

Research has provided support for the hypothesis that anxious individuals are slower to disengage attention from threat stimuli. Amir, Elias, Klumpp, and Przeworski (2003) found that individuals with social phobia had difficulty disengaging attention from social threat words (e.g., embarrassed, humiliated) when compared with a control group. Fox, Russo, and Dutton (2002) found that individuals with high trait anxiety, in comparison to individuals with low trait anxiety, had greater difficulty disengaging attention from emotional faces (angry and happy), but not neutral faces. Derryberry and Reed (2002) used a spatial cueing task to examine attention to threat cues at high and low levels of trait anxiety. Additionally, participants completed a self-report measure of AC (i.e., the Attentional Control Scale [ACS]; described below). As expected, individuals high in trait anxiety were slower to disengage attention from threat cues. However, individuals high in trait anxiety and high in AC showed significantly faster disengagement from threatening cues than participants high in trait anxiety and low in AC. In addition to supporting a delayed disengagement model of attentional threat bias, these findings provide evidence that higher order regulatory processes can attenuate automatic responding at a relatively early stage of information processing; and furthermore, after accounting for the detrimental effects of anxiety on attention, AC can still benefit individuals with higher levels of anxiety.

In an examination of more distal effects of AC, Bardeen and Read (2010) examined the degree to which AC predicted recovery from trauma re-telling negative mood. Trauma exposed participants provided a baseline measure of negative affect and AC (i.e., ACS), gave a first person account of their most distressing traumatic event, and then completed two subsequent post-trauma re-telling measures of state affect. Trauma-exposed individuals with high AC recovered faster from trauma re-telling induced negative mood than individuals low in AC, suggesting that distress is reduced by disengaging and shifting attention from trauma information (Bardeen & Read, 2010). Furthermore, mild distraction may help to expedite fear reduction during exposure therapy (Johnstone & Page, 2004). Therefore, AC may aid individuals with PTSD during exposure therapy by decreasing their level of fear during treatment, thus making treatment tolerable and increasing the likelihood that the client will continue attending exposure sessions rather than exhibiting escape and avoidance behaviors. Consistent with this view, Foa and Kozak (1986) hypothesized that emotional processing, a necessary component of successful exposure therapy for PTSD, is unlikely when a client's level of fear is too high. Distraction may help to bring one's level of fear into a range in which emotional processing can occur.

To our knowledge, only two published studies have examined the specific attentional processes (i.e., facilitated engagement, difficulty disengaging) underlying attentional biases associated with PTSS. Pineles, Shipherd, Welch, and Yovel (2007) assigned Vietnam-era veterans ($N = 57$) into high- and low-PTSD groups based on self-reported PTSS and had all participants complete a visual search task with the goal of identifying an "odd-ball," or discrepant target among a group of identical stimuli. Participants high in PTSS, compared to those low in PTSS, had difficulty disengaging from trauma stimuli, as represented by slower identification of neutral word targets embedded in a group of Vietnam-related threat words in comparison to trials in which a neutral word target was embedded in a group of neutral words (i.e., "interference condition"). No evidence of facilitated threat engagement was found (i.e., "facilitation condition": faster identification of Vietnam-related threat word targets embedded in a group of neutral words). Pineles, Shipherd, Mostoufi, Abramovitz, and Yovel (2009) replicated these findings in a group of sexual assault survivors ($N = 46$), finding evidence of difficulty disengaging from sexual assault-related threat words (e.g., scream, struggle) among participants with high self-reported PTSS.

These findings are the first to identify difficulty disengaging from threat stimuli as the attentional process underlying attentional biases in those with higher PTSS and they provide evidence contradicting the vigilance-avoidance model, with neither study finding facilitated threat engagement among those with higher PTSS. Interestingly, task order effects were shown in both studies; that is, among participants in the high-PTSD group, only those who completed the interference condition first, followed by the facilitation condition, showed evidence of difficulty disengaging from trauma stimuli relative to those in the low-PTSD group. As discussed by Pineles et al. (2009), difficulty disengaging from trauma stimuli may not have been observed among those high in PTSS who completed the interference condition second, because participants had already been exposed to the trauma words many times in the first condition. In other words, a process of habituation may have occurred, with trauma stimuli losing their potency over many trials. However, the use of word stimuli, which require greater semantic processing (Pineles et al., 2009), and are more prone to subjective familiarity and frequency of use than pictorial stimuli (Bradley et al., 1997), may have increased error variance, thus obscuring potentially important effects.

In addition, the relatively small sample size in both studies (i.e., Study 1: $N = 57$, Study 2: $N = 46$) suggests the possibility of insufficient power to detect effects. For example, Pineles et al. (2009) found no association between group status and a bias for attending to general threat-related words, however, it may be the case that there was insufficient power to detect an association between general threat stimuli and attentional disengagement among individuals with higher PTSS. Furthermore, due to the small sample size, Pineles et al. (2009) did not examine the extent to which the association between PTSS and difficulty disengaging from trauma stimuli was accounted for by state anxiety. Building on the work of Pineles and colleagues, future research examining associations between attentional threat bias and PTSS would benefit from (a) the use of pictorial stimuli, which are thought to induce emotional valence at a more visceral level than word stimuli (Bradley et al., 1997), (b) increasing the sample size in order to account for state levels of anxiety in analysis, (c) the use of an experimental paradigm which can dileneate the temporal sequence of attentional processes, and (d) examining potential associations between AC, attentional disengagement difficulties, and PTSS.

1.3. *The fear network*

The fear network model of PTSD (Foa & Kozak, 1986) explains the automaticity of threat processing in PTSD by describing a network of interconnected trauma memory nodes which are hypothesized to be linked by a process of spreading activation. The triggering of one node in the network, presumably by threat-relevant stimuli in one's environment, causes spreading activation across the network and a subsequent triggering of all other nodes, thus resulting in a response consistent with the physiological symptoms in PTSD (e.g., reexperiencing, hyperarousal).

The fear network model, in its present form, suggests that exposure therapy is effective in treating PTSD because pathological associations in the fear network are weakened when exposure to threat stimuli is coupled with disconfirmation of feared outcomes, a process of unlearning (Foa, Huppert, & Cahill, 2006). However, recent evidence has provided a different conceptualization of the underlying mechanisms in exposure therapy. This evidence suggests that extinction is not a matter of unlearning, but rather new learning; that is, extinction does not occur through a disintegration of associations in the network, but by establishing new associations that inhibit pathological responses to conditioned stimuli (Bouton, 2002; McNally, 2007; Myers & Davis, 2002). Because executive attentional mechanisms have been shown to inhibit dominant reflexive responses (e.g., eye blink responses to startle probes; Gyurak & Ayduk, 2007), the effects of attentional training on one's ability to use higher order executive attention should presumably aid in the extinction process, thus reducing PTSS.

The fear network model has provided us with an important conceptualization of bottom-up threat processing in PTSD. However, to maintain consistency with current research, which has shown that top-down AC can attenuate bottom-up attentional processing relatively quickly, and to maintain consistency with other empirically supported models (i.e., Corbetta & Shulman, 2002; Eysenck et al., 2007; Metcalfe & Mischel, 1999), fear-network models of information processing would be well served by incorporating higher-level executive processes into an overarching model.

1.4. Disengaging from threat stimuli: adaptive or avoidant?

As previously mentioned, mild distraction may help to expedite fear reduction during exposure to threat stimuli (Johnstone & Page, 2004). Therefore, the ability to intentionally disengage from threat-related stimuli may help to attenuate distress, thereby allowing one to remain in and learn from the environment rather than feeling the need to escape from an environment where the threat remains salient. Consistent with this proposition, shifting attention to safe or novel stimuli can help to reduce negative affect (Harman, Rothbart, & Posner, 1997; Nolen-Hoeksema & Morrow, 1993). On the other hand, it could be argued that shifting attention away from threatening information is maladaptive (i.e., experiential avoidance), eventually leading to problematic avoidance behaviors (e.g., social phobia, agoraphobia); however, research to date suggests that this form of attentional avoidance is adaptive (e.g., Eisenberg, Fabes, Guthrie, & Reiser, 2000).

Attention regulation capabilities have been shown to be protective against negative emotionality and externalizing behaviors and positively associated with social adaptation (Eisenberg et al., 2000). In college students, better attentional disengagement and shifting abilities, measured via a covert attentional orienting task, predicted less negative affect after a laboratory induction of negative mood (Compton, 2000) and self-reported AC, measured using the ACS, has been shown to predict less negative affect following trauma re-telling (Bardeen & Read, 2010). AC, measured via the ACS, is positively associated with indices of positive emotionality, such as extraversion, and inversely related to aspects of negative emotionality, such as trait anxiety (Derryberry & Reed, 2002).

In light of the role of AC in the experience and modulation of negative affect, it stands to reason that AC may be an important individual difference factor in post-trauma adaptation and the maintenance of PTSS. Therefore, among individuals with PTSD, an inability to disengage attention from threat-relevant information may help to maintain and prolong the rumination and reexperiencing seen in PTSD; better AC abilities may facilitate recovery among individuals with PTSD.

2. Present study

To date, research on attention allocation in PTSD has focused primarily on fast, automatic responding to threat stimuli. The modified Stroop effect, considered by many to be a robust phenomenon in the extant literature (Buckley et al., 2003; Constans, 2005; McNally, 1998), has been presented as evidence of facilitated engagement toward threat stimuli in those with PTSD. However, consistency of this evidence has recently been called into question (Kimble et al., 2009). Furthermore, use of the modified Stroop paradigm to examine attention to threat in PTSD has been criticized on the grounds that the task fails to provide an independent measure of both fast and slow effects of attention to threat stimuli. More specifically, the evidence for fast, automatic effects in the modified Stroop is lacking and the task does not provide an independent measure of one's ability to disengage from threat stimuli (Bar-Haim et al., 2007; McKenna & Sharma, 2004), an ability which has been shown to account for attentional threat bias in individuals with higher levels of anxiety (Amir et al., 2003; Derryberry & Reed, 2002; Fox et al., 2002). In addition, preliminary research has shown difficulty disengaging from trauma stimuli among those with higher PTSS (Pineles et al., 2007, 2009).

The primary aim of the present study is to examine PTSS as a predictor of attention to general threat stimuli using an experimental paradigm that allows differentiation among the effects of fast, facilitated engagement toward threat stimuli and difficulty disengaging from such stimuli. Based on the findings of recent anxiety (Amir et al., 2003; Derryberry & Reed, 2002; Fox et al., 2002) and PTSS research (Pineles et al., 2007, 2009), we expect that individuals with higher levels of PTSS will attend to threat stimuli longer than individuals low in PTSS as a result of greater difficulty disengaging attention from threat stimuli. Further, we expect that PTSS will not predict facilitated engagement toward threat stimuli, as there has been, to date, a lack of evidence supporting this proposition (Bar-Haim et al., 2007; McKenna & Sharma, 2004; Pineles et al., 2007, 2009).

Research examining whether individuals with higher PTSS can regulate attention using higher order cognitive mechanisms (i.e., AC) is lacking; thus, another aim of the present study is to investigate associations among executive attention (i.e., attentional control), attentional threat bias, and PTSS. Higher AC has been found to predict better affect regulation abilities (Bardeen & Read, 2010; Compton, 2000) and is associated with measures of positive emotionality (e.g., openness to experience, positive affect, extraversion) and is inversely related to measures of negative emotionality (e.g., trait anxiety, neuroticism; Derryberry & Reed, 2002; Eisenberg et al., 2000). Therefore, we predict that PTSS will be inversely related to AC; in other words, AC abilities will likely be reduced with the increasing levels of anxiety and arousal that are indicative of posttraumatic stress symptomatology.

In addition, higher order regulatory processes have been shown to attenuate automatic responding at a relatively early stage of information processing (Gyurak & Ayduk, 2007). High AC has been shown to account for faster disengagement from threat stimuli, even in individuals with higher levels of anxiety (Derryberry & Reed, 2002). However, degree to which threat stimuli are fear inducing is thought to be instrumental in determining the balance between bottom-up and top-down attentional processing, with higher levels of fear induction associated with impaired top-down AC (Bishop, 2008; Eysenck et al., 2007). With this in mind, the present study incorporated the use of negatively valenced emotional images supported by a large database of normative valance and arousal ratings (International Affective Picture System [IAPS]; Lang, Bradley, & Cuthbert, 1999) with the intention of examining AC as a moderator of the relationship between attention to threat stimuli and PTSS. As mentioned above, we expected that individuals with low PTSS would disengage faster from threat stimuli than individuals with high PTSS; however, among individuals with high PTSS, we expected that those with high AC would disengage and shift attention significantly faster from threat stimuli than those with low AC.

To summarize, we predicted that individuals with higher levels of PTSS would attend to threat stimuli longer, not as the result of faster shifting toward threat stimuli, but as the result of having greater difficulty disengaging from such stimuli. Next, we predicted that there would be an inverse relationship between PTSS and AC. Finally, we predicted that AC would moderate the relationship between PTSS and attention to threat stimuli, with individuals high in PTSS and high in AC disengaging and shifting attention significantly faster from threat stimuli than those with high PTSS and low AC.

3. Method

3.1. Participants

Participants ($N = 97$; 56 women) were introductory psychology students recruited from a mass testing pool at a mid-sized university in the Midwest. The average age of this sample was 19.2 years (*SD* = 1.9). Fifty-eight percent self-identified as Caucasian, 24% as Black, 9% as Hispanic or Latino, 5% as Asian, and 4% endorsed "other"; most were freshmen (71%). Eighty-eight percent of participants reported that they were right-hand dominant.

3.2. Procedure

At a single experimental session, participants completed informed consent, provided demographic information, filled out a battery of self-report measures, and then completed two stimulus-response tasks (i.e., dot-probe task, Attention Network Test; Fan, McCandliss, Sommer, Raz, & Posner, 2002). The presentation of these tasks was counterbalanced across participants to account for order effects. After completing both stimulus-response tasks, participants were debriefed and given partial course credit for their introductory psychology course. The present study focuses on a subset of measures from a larger assessment battery and only one of the stimulus-response tasks (i.e., the dot-probe task).[1]

3.3. Equipment

SSI Web software (Orme, 2005) was used to present self-report measures on a Dell Dimension 8300 desktop computer with a 19-in. monitor. At a second work station in the same room, participants completed the dot-probe task on a Dell Dimension 8300 computer with a 17-in. flat screen monitor. Participants were seated approximately 50 cm from the computer monitor during the dot-probe task and they used a computer keyboard to respond to the task. Stimuli were presented and responses were recorded using DirectRT software (version 2006.1; Jarvis, 2006).

3.4. Dot-probe task

To date, it has been difficult to determine whether individuals with PTSD have a specific bias for attending to trauma stimuli or a more general bias for attending to negatively valenced information because the majority of research in this area has used only trauma-specific stimuli (Buckley, 2000). Thus, the present study incorporated 40 general threat (e.g., man with knife, poisonous snake, plane crash, vicious dog, bloody assault victim) and 80 neutral images (e.g., spoon on table, umbrella, woman on telephone), which were identified for inclusion as either general threat or neutral stimuli based on ratings of valence (*M* = 2.17 and 5.12, respectively) and arousal (*M* = 6.52 and 2.96, respectively; IAPS; Lang et al., 1999). Thus, general threat stimuli were negatively valenced and highly arousing, whereas neutral stimuli elicited neither negative nor positive affect and had low arousal ratings. IAPS images with negative valence and higher arousal ratings have been shown to produce negative affective states in participants in a number of studies (e.g., Erk et al., 2003; Pretz, Totz, & Kaufman, 2010).

Prior to starting the dot-probe task, participants were provided with a standard set of instructions which directed them to press the arrow key (left or right) on the computer keyboard that was consistent with the relative position of a dot that would appear on the computer screen. Participants were told to respond as quickly and accurately as possible every time the dot was presented. Each trial began with a fixation cross presented in the center of the screen for 1000 ms. Next, two images appeared side by side on the screen (i.e., neutral–neutral or threat–neutral) for either 150 ms or 500 ms. Immediately following the stimulus presentation, a dot appeared in place of one of the images and remained on the screen until the participant responded. Participants completed 10 practice trials with all stimuli consisting of neutral–neutral image pairings. Following the practice trial, participants completed one continuous block of 60 trials (20 neutral–neutral and 40 neutral–threat stimulus pairs). Participants were presented with an equal number of trials of each condition (i.e., 150 ms and 500 ms), with the order of conditions (i.e., timing, image type) randomized across participants.

3.5. Self-report measures

Potential covariates. Demographics (i.e., sex, age, race) and order of stimulus-response task presentation (i.e., dot-probe task, Attention Network Test) were examined as potential covariates in data analysis. Race (coded as Black [*n* = 23, 24%], White [*n* = 56, 58%], and Other [*n* = 18, 19%]) was dummy coded as two variables, non-Black versus Black, and non-White versus White. Task order was coded as one dichotomous variable, ANT presented first versus dot-probe task presented first.

Traumatic Life Events Questionnaire (TLEQ). Lifetime trauma exposure was assessed via the Traumatic Life Events Questionnaire (TLEQ; Kubany et al., 2000). The TLEQ assesses exposure to 22 potentially traumatic events (e.g., motor vehicle accident, physical and sexual assault, life-threatening illness), asking participants to report ("yes" or "no") events that they have experienced (Criterion A1; APA, 2000). For each potentially traumatic event that is endorsed, a follow-up question assesses whether participants experienced intense fear, helplessness, or horror in response to the event (Criterion A2; APA, 2000). The TLEQ has demonstrated good psychometric properties, including test–retest reliability, convergent validity with other common measures of trauma, and has been used in a range of populations (Kubany et al., 2000). Eighty-seven (90%) participants reported that they had experienced at least one potentially traumatic event in their lifetime (Criterion A1),[2] and of these, 75 (86%) reported the subjective experience of fear, helplessness, or horror in response to their most distressing potentially traumatic event (Criterion A2).

PTSD Checklist-Civilian Version (PCL-C). Participants who reported experiencing at least one Criterion A1 potentially traumatic event were instructed to complete the PCL-C in reference to the potentially traumatic event(s) that they endorsed. Participants who did not report experiencing a potentially traumatic event were instructed to complete the PCL-C in reference to how they respond to stressful experiences more generally.[3] The PCL-C

[1] The Attention Network Test (ANT; Fan et al., 2002) was designed to provide independent measures of three attentional processes (i.e., alerting, orienting, executive control). However, recent research suggests that there is significant overlap in the measurement of these attentional processes as measured via the ANT (e.g., Ishigami & Klein, 2010; Redick & Engle, 2006). Thus, for the sake of parsimony in clarifying associations among PTSS, AC, and attentional threat bias, the ANT was excluded from the present study.

[2] On average, participants reported experiencing approximately three potentially traumatic events (Criterion A1; *M* = 3.4, *SD* = 2.6; range 1–12 events). Of those who experienced at least one potentially traumatic event in their lifetime (*n* = 87), the top five potentially traumatic events included the sudden unexpected death of loved one (*n* = 65; 67%), a loved one survived a life threatening illness (*n* = 36; 37%), natural disaster (*n* = 31; 32%), mass violence (e.g., shooting, bombing, terrorism; *n* = 25; 26%), other events that were life threatening, caused serious injury, or were highly disturbing (*n* = 23; 24%), and threat of death or serious physical harm (*n* = 20; 21%). Additionally, participants were asked to identify the event, from the events they reported experiencing, that caused them the most distress. Of those who experienced at least one potentially traumatic event in their lifetime (*n* = 87), the top five potentially traumatic events that were identified as being *most distressing* included the sudden unexpected death of loved one (*n* = 35; 40%), a loved one survived a life threatening illness (*n* = 9; 10%), sexual assault (*n* = 7; 8%), abortion (*n* = 7; 8%), and natural disaster (*n* = 6; 7%).

[3] Results were unchanged when participants who did not report experiencing a potentially traumatic event (*n* = 10) were removed from the sample; that is, statistically significant associations remained significant and nonsignificant findings were unchanged.

(Weathers, Huska, & Keane, 1991) is a 17-item self-report measure specifically designed to assess Criteria B, C, and D of the DSM-IV-TR PTSD construct in a civilian population. Response options are rated on a 5-point scale, indicating the extent to which respondents have experienced each symptom in the past month. The PCL-C has exhibited high internal consistency and high test–retest reliability from one hour to one week (Ruggiero, Del Ben, Scotti, & Rabalais, 2003). Furthermore, the PCL was predictive of PTSD as assessed by the SCID (First, Spitzer, Gibbon, & Williams, 1994); using a cut score of 50 resulted in a specificity of .83 and a sensitivity of .82 (Blanchard, Jones-Alexander, Buckley, & Forneris, 1996). The PCL is highly correlated with similar self-report measures (e.g., Mississippi Scale for Combat Related PTSD [α = .93], Impact of Event Scale [α = .90]; Weathers, Keane, & Davidson, 2001). These psychometric properties have been validated in a variety of populations (e.g., motor vehicle accident survivors, sexual assault victims; Blanchard et al., 1996; Weathers et al., 1993). Internal consistency in this sample for the PCL-C total score was excellent (α = .92).

Attentional Control Scale (ACS). The ACS (Derryberry & Reed, 2002) is a 20-item self-report measure that assesses one's ability to flexibly control attention. Three subfactors have been identified through factor analysis: (a) attention shifting (e.g., "I can quickly switch from one task to another"), (b) focusing of attention (e.g., "When concentrating, I can focus my attention so that I become unaware of what's going on in the room around me"), and (c) the ability to flexibly control thought (e.g., "It is hard for me to break from one way of thinking about something and look at it from another point of view"; Derryberry & Reed, 2002). The ACS shows good internal consistency (α = .88; Derryberry & Reed, 2002). Further, the ACS is associated with measures of positive emotionality and inversely related to measures of negative emotionality (Derryberry & Reed, 2002) and higher scores are predictive of increased activation in brain areas associated with top-down emotion regulation (Matthews, Yiend, & Lawrence, 2004). Internal consistency in this sample for the ACS total score was good (α = .82).

State-Trait Anxiety Inventory (STAI). The STAI (Spielberger, 1983) consists of two 20-item scales which ask participants to rate how they feel "right now" (state anxiety) and how they "generally feel" (trait anxiety) in reference to a series of statements (e.g., "I feel pleasant," "I feel like a failure") on a 4-point Likert-type scale with "Almost Never" and "Almost Always" serving as scale anchors. Both scales have evidenced good to excellent internal consistency (α = .86 to .95) in a variety of different samples (e.g., college students, adults, military personnel, high school students; Spielberger, 1983). Test–retest reliability was found to be adequate at a 30-day interval (α = .71 to .75; Spielberger, 1983). Internal consistency in this sample for the STAI-State scale was excellent (α = .92). State anxiety was used as a covariate in analyses to examine the degree of specificity in the association between PTSS and attention to threat stimuli.

4. Results

4.1. Preparation of stimulus-response data

Reaction times for correct responses on the dot-probe task were used in analysis. Across participants, 99.4% of dot-probe trials had correct responses and no single participant had more than 3 out of 60 (5%) incorrect responses. Response times less than 200 ms and greater than three standard deviations above the mean response time for each trial were discarded in order to reduce the effect of anticipatory responding and outliers (Salemink et al., 2007). Less than 1% of responses were either incorrect or fell outside of the above timing guidelines. Two attentional bias scores were calculated based on stimulus presentation time (i.e., 150 ms, 500 ms). Attentional bias was calculated by subtracting trials where the probe occurred in the position of a threat image from trials where the probe occurred in the position of a neutral image in neutral–threat pairings (Frewen, Dozois, Joanisse, & Neufeld, 2008; MacLeod, Mathews, & Tata, 1986). Negative attentional bias scores indicate attention to neutral simuli and positive attentional bias scores indicate attention to threat stimuli.

4.2. Preliminary analyses

Means, standard deviations, and bivariate correlations were calculated in order to better understand the association between descriptive statistics (sex, age, race) and variables of interest (i.e., attentional bias at 150 ms and 500 ms, ACS total score, PCL-C total score, PCL-C cluster scores [reexperiencing, avoidance, hyperarousal], STAI-State subscale score, task order). In addition, examination of bivariate correlations served to (a) test the hypothesis that there would be an inverse relationship between PTSS and AC, (b) confirm discriminant and convergent validity (i.e., that constructs were related to each other in predicted ways), and (c) determine which variables should be included in multiple regression analysis. Cronbach's alpha was calculated to examine the internal consistency of the following self-report measures: PCL-C, ACS, STAI-State scale. See Table 1 for means, standard deviations, and bivariate correlations.

As predicted, PTSS (i.e., PCL-C) were inversely related to AC (i.e., ACS). Additionally, two out of three PCL-C subscales (i.e., reexperiencing, hyperarousal) were inversely related to AC. Furthermore, the PCL-C total score and two of three PCL-C subscales (i.e., reexperiencing, hyperarousal) were positively associated with attentional bias at 500 ms, but not at 150 ms. In other words, higher PTSS were associated with greater attention to threat stimuli when stimuli were presented for 500 ms, but not at the shorter presentation time of 150 ms. At the bivariate level, AC was not associated with attentional bias at either stimulus presentation duration. As expected, state anxiety was positively associated with all PTSS variables and was inversely associated with AC. Consistent with findings showing that women report more PTSS than men (e.g., Norris, Foster, & Weisshaar, 2002; Tolin & Foa, 2006), sex (1 = male and 2 = female) was positively associated with the PCL-C and two of the three PCL-C subscales (i.e., reexperiencing, avoidance). Race (% Black: 1 = non-Black and 2 = Black) was positively associated with the ACS total score; that is, participants who identified themselves as Black reported significantly higher AC than participants who self-identified with any other racial category. Accordingly, sex and race (% Black) were included as covariates in multivariate analyses. Additionally, the STAI-State scale was used as a covariate in multivariate analyses to examine the degree of specificity in the relationship between PTSS and attentional threat bias. At the bivariate level, task order and race (% White) were not associated with any of the variables of interest. Task order was excluded from further analysis, while race (% White) was included as a covariate in analyses in order to cover all three categories of the race variable.

4.3. Regression models

A series of hierarchical multiple regressions was conducted in order to test study hypotheses. In the first step of the model, sex, race (% Black), race (% White), and state anxiety (i.e., STAI-State scale) served as predictor variables and attentional bias at 150 ms SOA served as the outcome variable. In the second step, PTSS (i.e., PCL-C) was entered into the model as a predictor variable. In the final step, AC (i.e., ACS) and an interaction term comprised of AC and PTSS were entered into the model as predictor variables. This series of hierarchical regressions was repeated with only one change;

Table 1
Descriptive statistics and correlations.

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Sex	–											
2. Race (% White)	−.31*	–										
3. Race (% Black)	.28*	−.65*	–									
4. Task order	−.01	.16	−.10	–								
5. PCL total score	.26*	.01	−.12	.06	.92							
6. PCL reexperiencing	.27*	.07	−.09	−.01	.90*	–						
7. PCL avoidance	.25*	−.06	−.10	.09	.94*	.77*	–					
8. PCL hyperarousal	.19	.04	−.15	.06	.90*	.72*	.76*	–				
9. Attentional control scale	−.06	.06	.26*	.11	−.24*	−.20*	−.18	−.28*	.82			
10. AB 150 ms	−.01	.02	−.09	.06	−.01	−.01	−.10	.09	−.14	–		
11. AB 500 ms	.11	.04	−.09	−.02	.23*	.24*	.17	.23*	.01	.21*	–	
12. STAI-State	.10	.08	−.12	.03	.52*	.44*	.44*	.56*	−.30*	.14	.04	.92
M	1.6	.58	.24	1.4	29.3	8.6	11.9	8.7	50.8	3.6	10.9	35.3
SD	.50	.50	.43	.5	12.3	4.1	5.3	4.1	7.6	32.0	48.9	10.2
Minimum	0	0	0	0	17	5	7	5	31	−116.3	−112.4	20
Maximum	1	1	1	1	74	25	28	23	68	193.7	75.9	67
N	97	97	97	97	97	97	97	97	97	97	97	97

Note. Coefficient alphas (where appropriate) are on the diagonal. Sex = (1 = male, 2 = female); race (% White) = (0 = non-white, 1 = white); race (% Black) = (0 = non-black, 1 = black); task order = (1 = Attention Network Test completed first, 2 = dot-probe task completed first); PCL = Posttraumatic Stress Disorder Checklist-Civilian version; PCL reexperiencing = PCL reexperiencing subscale score; PCL avoidance = PCL avoidance subscale score; PCL hyperarousal = PCL hyperarousal subscale score; AB 150 ms = attentional bias when stimulus onset asynchrony was 150 ms; AB 500 ms = attentional bias when stimulus onset asynchrony was 500 ms; STAI-State = State-Trait Anxiety Inventory State Scale.

* $p < .05$.

attentional bias at 500 ms SOA replaced attentional bias at 150 ms SOA as the outcome variable.

Predicting attentional bias at 150 ms SOA. As seen in Table 2, there was no main effect of PTSS on attentional bias at 150 ms SOA, *ns*; however, in the final step of the model, the interaction term (AC × PTSS) was a significant predictor of attentional bias at 150 ms SOA, $p < .05$. None of the covariates was a significant predictor of attentional bias at 150 ms SOA, *ns*.

The interaction term was probed using simple slopes analysis (Aiken & West, 1991). Results revealed that there was no association between AC and attentional bias at 150 ms SOA for participants with low PTSS ($B = .20$, $\beta = .05$, $p > .05$). However, there was a significant positive association between AC and attentional bias at 150 ms SOA for participants with high PTSS ($B = -1.93$, $\beta = -.46$, $p < .05$). Participants low in AC and high in PTSS were more likely to attend to threat stimuli and participants high in AC and high in PTSS were more likely to attend to neutral-stimuli when SOA was 150 ms (see Fig. 1).

Predicting attentional bias at 500 ms SOA. As predicted, there was a significant main effect of PTSS on attentional bias at 500 ms SOA, $p < .05$ (see Table 2). The association was positive; that is, higher PTSS were associated with greater attention to threat stimuli when SOA was 500 ms. In the final step, when AC and the interaction term (AC × PTSS) were entered into the model, the association between PTSS and attentional bias at 500 ms SOA was reduced to marginal significance ($p = .069$), with a small to medium effect size ($\beta = .23$). AC, the interaction term, and all of the covariates were not associated with attentional bias at 500 ms SOA, *ns*.

Table 2
Hierarchical multiple regressions with attentional bias at 150 ms SOA and 500 ms SOA as outcome variables.

Predictor	Attentional bias (150 ms SOA)			Attentional bias (500 ms SOA)		
	B	*β*	ΔR^2	*B*	*β*	ΔR^2
Step 1			−.02			−.01
Sex	−.87	−.01		14.49	.15	
Race (% Black)	−8.07	−.11		−15.23	−.13	
White (% White)	−3.99	−.06		−.31	.00	
State anxiety	.40	.13		.03	.01	
Step 2			−.02			.02**
Sex	1.22	.02		8.30	.08	
Race (% Black)	−9.81	−.13		−10.07	−.09	
White (% White)	−4.55	−.07		1.37	.01	
State anxiety	.60	.19		−.56	−.12	
PTSS	−.35	−.13		1.03	.26**	
Step 3			.02*			.02
Sex	−1.40	−.02		6.51	.07	
Race (% Black)	−4.15	11.10		−12.46	−.11	
White (% White)	−.14	.00		.25	.00	
State anxiety	.54	.17		−.46	−.10	
PTSS	−.49	−.19		.92	.23*	
AC	−.68	−.16		.25	.04	
PTSS × AC	−.09	−.25**		−.08	−.14	

Note. $N = 97$. SOA = stimulus-onset asynchrony; PTSS = posttraumatic stress symptoms (i.e., PCL-C); AC = attentional control (i.e., ACS); PTSS × AC = interaction term; race (% Black) = (non-black/black); race (% White) = (non-white/white); state anxiety = STAI-State scale.

* $p < .07$.

** $p < .05$.

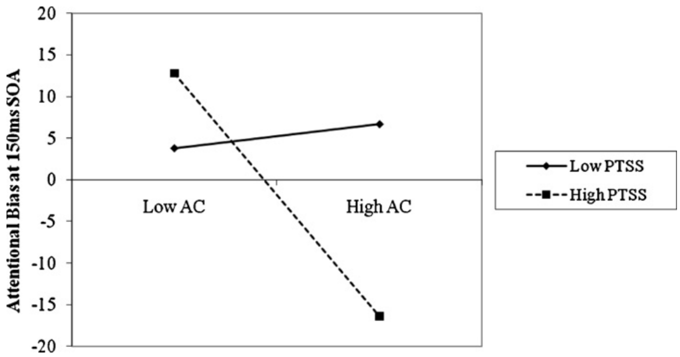

Fig. 1. Interaction effect: (AC × PTSS) was a significant predictor of attentional bias at 150 ms SOA, $B = .09$, $\beta = -.24$, and $p < .05$. Simple slopes analysis revealed that participants low in AC and high in PTSS were more likely to attend to threat stimuli and participants high in AC and high in PTSS were more likely to attend to neutral stimuli when SOA was 150 ms.

5. Discussion

As predicted, higher posttraumatic stress symptoms predicted a bias for attending to threat stimuli, findings that appear to be consistent with previous literature suggesting an attentional bias for threat-related information in PTSD (e.g., Beck et al., 2001; Bryant & Harvey, 1997; Litz et al., 1996; McNally et al., 1996, 1990). However, in contrast to facilitated engagement conceptualizations of attentional threat bias in PTSD (i.e., vigilance-avoidance; Weierich et al., 2008), our results are more consistent with a disengagement difficulty model (i.e., attention maintenance; Weierich et al., 2008). Participants higher in PTSS had greater difficulty disengaging from threat stimuli in comparison to participants low in PTSS who seem to have disengaged and shifted their attention from threat stimuli by 500 ms in favor of attending to neutral stimuli.

Evidence of facilitated threat engagement among participants high in PTSS was lacking, results which may seem counterintuitive at first glance, as hypervigilance is one of the hallmark features of PTSD (APA, 2000). However, individuals with PTSD are likely to be tense, on guard, and experiencing anxious arousal when hypervigilant. A state of hypervigilance may increase the amount of time one spends scanning the environment for threat, but is unlikely to facilitate threat engagement more generally in individuals with PTSD, as precise threat detection is likely to be more difficult when one is experiencing symptoms of hyperarousal (e.g., irritability, difficulty concentrating). Furthermore, our findings are consistent with theories of attention (i.e., Corbetta & Shulman, 2002; Eysenck et al., 2007; Metcalfe & Mischel, 1999) which suggest that individuals in a heightened state of anxious arousal will be less successful at tasks in which the executive attentional mechanisms of inhibition and shifting are needed. Consistent with this conceptualization and our prediction, PTSS were found to be inversely related to AC. Individuals with higher PTSS had a relative deficit in their ability to disengage attention from threat images using AC.

In addition, it seems likely that threat images were more stress-inducing to individuals with higher PTSS, which further decreased their ability to use AC to disengage from threat stimuli. However, it is important to note that the association between PTSS and the ability to disengage from threat stimuli was significant after accounting for state anxiety, thus suggesting that the association between PTSS and attention to threat stimuli is not better accounted for by one's general level of anxious arousal.

Although our findings are consistent with research suggesting that anxious individuals are slower to disengage from threat information (e.g., Amir et al., 2003; Derryberry & Reed, 2002; Fox et al., 2002), we cannot say with certainty that PTSD symptomatology is not associated with facilitated threat engagement. It appears that our experimental paradigm, in which facilitated engagement was measured after a SOA of 150 ms, may have provided enough time for the shifting and disengaging functions of AC to occur. The speed with which higher order executive attentional processes can effect responding is unknown, as this is a relatively new area of research. The results of our moderation analysis, in which AC moderated the relationship between PTSS and attentional bias at 150 ms SOA, suggest that AC can affect responding as early 150 ms. Although we predicted an AC moderation effect (i.e., individuals high in PTSS and high in AC would disengage and shift attention from threat stimuli significantly faster than those with high PTSS and low AC), we expected the effect to occur at the longer SOA of 500 ms, under the presumption that higher order attentional processes, which have been conceptualized as occurring more slowly in relation to bottom-up attentional processes, would take longer than 150 ms to be employed.

Taken together, our findings support a conceptualization of attention to threat stimuli in which there is competition between bottom-up and top-down attentional processes and a limited capacity of attentional resources, which can be exhausted under conditions of high "perceptual load" (Lavie et al., 2004). It has been suggested that competition between bottom-up and top-down attentional systems is affected not only by one's general level of distress (e.g., PTSS), but also by factors such as stimulus presentation time, the saliency or intensity of threat (stimulus valence), and competition with other stimuli for processing resources (Bishop, 2008). Even though a shorter duration SOA (i.e., 150 ms) would be expected to increase perceptual load due to the necessity of faster responding, stimulus valence may increase perceptual load to a greater degree among susceptible individuals (i.e., high PTSS) at longer SOA's, as threat stimuli are likely more salient at these longer presentation durations (i.e., 500 ms).

Our findings support this conceptualization. Participants with high PTSS and high AC were able to shift and disengage from threat stimuli using top-down AC when SOA was 150 ms, suggesting that the level of perceptual load was lower in this condition as the stimulus valence of threat stimuli was less salient at this short presentation duration. Additionally, as suggested by Metcalfe and Mischel (1999), bottom-up activation is more likely to trigger AC in individuals with better developed executive attentional systems, with AC eventually becoming an almost automatic response to bottom-up dominant responding. Thus, when the salience of threat stimuli was decreased, participants high in AC and high in PTSS were able to disengage and shift attention from threat stimuli. However, when the stimulus presentation duration was increased to 500 ms, perceived threat intensity was likely increased; and thus, individuals higher in PTSS were unable to use AC to disengage attention from threat stimuli because attentional resources were otherwise occupied. In contrast, individuals with lower PTSS were able to disengage and shift attention from threat stimuli when SOA was 500 ms because the demand on bottom-up attentional resources was relatively low.

In contrast to previous research (e.g., Pineles et al., 2007, 2009), our findings suggest that attentional disengagement difficulties associated with PTSS are not limited to trauma-specific stimuli. Our findings suggest that the cognitive and behavioral manifestations of PTSD may be elicited by environmental stimuli that are seemingly unrelated to one's traumatic event, thus increasing distress and decreasing one's functioning across a wide array of contexts. On the other hand, it could be argued that a bias for attending to general threat stimuli in individuals with higher PTSS is a by-product of attentional vigilance for signs of trauma-specific threat in the environment. However, our results suggest difficulty disengaging from threat stimuli among those with higher PTSS rather than facilitated threat engagement. Furthermore, even if the association between PTSS and general threat stimuli is a by-product of another association (i.e., trauma-specific stimuli and PTSS), they nevertheless become associated as conditioned stimuli with corresponding conditioned responses. Therefore, it may be inferred that trauma memory nodes exist as components of a larger fear network in which all fear-related associations are closely intertwined. For example, a picture of a poisonous snake, the triggering of its corresponding threat-related memory node, and subsequent psychological and physiological reactivity may activate memories of combat in war veterans or memories of sexual assault in rape victims.

This conceptualization is especially relevant to treatment considerations in PTSD, as it challenges the idea that it is vitally important to replicate trauma-specific sensory input in order to activate trauma memory nodes in the fear network during exposure therapy (Foa & Kozak, 1986). Our findings suggest the possibility that trauma-related memory nodes will be activated by threat stimuli that are seemingly unrelated. Thus, although the degree of association between nodes in the fear network is likely closer among trauma-related stimuli than between general threat stimuli and trauma stimuli, the difference in the degree of association between nodes in the network may be of less importance in the therapeutic context than previously thought.

5.1. Limitations and future directions

Perhaps the most significant limitation in the present study is that the use of a SOA of 150 ms may have provided ample time for disengaging and shifting functions of AC to occur, therefore failing to capture more automatic, reflexive attentional processes. Thus, in addition to replication of the current findings, future research should examine shorter SOA's in order to better understand the temporal nature of attention to threat stimuli at different levels of PTSS.

In addition, our sample consisted solely of undergraduate students, the large majority of whom who were likely functioning at a higher level than individuals with PTSD in a clinical setting. Therefore, caution is warranted in generalizing these findings to a clinical population. Furthermore, in addition to state anxiety, which was accounted for in the present study, future research should examine associations among disorders that commonly co-occur with PTSD (e.g., panic disorder, substance use). Although difficulty disengaging from threat stimuli has previously been shown to be associated with high trait anxiety (Frewen et al., 2008; Salemink et al., 2007), an examination of a broader range of psychopathology will provide an understanding of the degree to which difficulty disengaging from threat stimuli is specific to anxiety-related pathology. It may be that disengagement difficulties are more generally related to an underlying pathological construct (e.g., negative affect).

Images used in the present study were not rated by study participants, and thus, the degree to which threat stimuli were unrelated to the individual traumatic experiences of the participants is unknown. While it would be methodologically ideal to choose stimuli that were completely unrelated to the individual traumatic experiences of the participants, this methodology would be extremely difficult to implement because participants had experienced approximately three potentially traumatic events on average. Further, to have the participants view the stimuli and make ratings prior to completing the dot-probe task would likely confound the results of the study, as image-related arousal would likely be reduced with repeated exposure to the stimuli. Therefore, it was our intention to identify threat images, which were pre-tested elsewhere (IAPS; Lang et al., 1999), of a wide variety that were negatively valenced and highly arousing. Negatively valenced and highly arousing IAPS images, such as those used in the present study, have been shown to produce negative affective states among participants in multiple studies (e.g., Erk et al., 2003; Pretz et al., 2010). In choosing threat images with a variety of themes, we intended to reduce trauma specific responding.

6. Conclusions

The present study serves to replicate findings from preliminary research which suggest that attentional bias associated with posttraumatic stress symptomatology is accounted for by difficulty disengaging from threat-related stimuli rather than enhanced threat engagement (Pineles et al., 2007, 2009). Furthermore, the present study extends previous work by suggesting that individuals with high PTSS have difficulty disengaging from threat stimuli in general, rather than having a trauma-specific attentional bias. This finding suggests that trauma memory nodes exist as components of a larger fear network in which all fear-related memories are closely intertwined and is consistent with the observation that the symptoms of PTSD generalize to contexts that are seemingly unrelated to one's traumatic event. This conceptualization has implications for exposure therapy for PTSD, as it suggests that the degree of match between stimuli present during the traumatic event and those presented during exposure therapy may be less important for accomplishing therapeutic outcomes than previously thought.

In addition, prolonged attentional engagement to threat information has been hypothesized to maintain and exacerbate the symptoms of PTSD (Constans, 2005; Elzinga & Bremner, 2002). Emotional processing, which is thought to be a necessary component of successful exposure therapy for PTSD, is thought to be unlikely when a client's level of fear is too high (Foa & Kozak, 1986). Thus, individuals with PTSD and higher AC abilities may fair better in exposure therapy when threat salience is at low to moderate levels because they may be better able to regulate negative affective states through a process of attentional disengagement and reengagement, which may decrease their level of fear during exposure sessions and make treatment more tolerable. These individuals may be more likely to continue attending exposure sessions rather than exhibiting escape and avoidance behaviors. Consistent with this view, evidence suggests that mild distraction may help to expedite fear reduction during exposure therapy (Johnstone & Page, 2004). Thus, the present findings, which suggest AC as a buffering mechanism against prolonged attentional engagement with threat-related stimuli among those with high PTSS when threat salience is at low to moderate levels, suggest that current PTSD interventions may benefit from incorporating attention based components.

To this end, research has shown that it is possible to increase one's ability to use higher level executive attention to regulate automatic emotional responses through clinical intervention (Jha, Krompinger, & Baime, 2007; Bherer et al., 2008). Furthermore, attention training interventions have been shown to be effective in significantly reducing social anxiety in individuals with a primary diagnosis of generalized social anxiety disorder (Schmidt, Richey, Buckner, & Timpano, 2009) and anxiety and depression in individuals with generalized anxiety disorder (GAD; Amir, Beard, Burns, & Bomyea, 2009). Effect sizes for Amir et al.'s (2009) Attention Maintenance Program was similar to those seen in psychological and pharmacological treatment studies.

These early findings are encouraging in that they show that the modification of attentional threat biases in those with GAD and SAD resulted in a reduction in client distress and associated psychopathology. Thus, attention modification holds promise for those suffering from psychopathology that is associated with a bias for attending to threat stimuli (e.g., PTSD). Based on the present work, future research would be well served by considering the role of higher order executive attention (i.e., attentional control) in alleviating distress through attention modification in individuals with anxiety-related pathology.

Acknowledgments

We thank Erin Stevens for her valuable assistance in editing this manuscript and Heather Giless for her assistance with data collection.

References

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.
American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text revision). Washington, DC: American Psychiatric Association.
Amir, N., Beard, C., Burns, M., & Bomyea, J. (2009). Attention modification program in individuals with generalized anxiety disorder. *Journal of Abnormal Psychology*, *118*, 28–33. doi:10.1037/a0012589
Amir, N., Elias, J., Klumpp, H., & Przeworski, A. (2003). Attentional bias to threat in social phobia: Facilitated processing of threat or difficulty disengaging attention from threat. *Behaviour Research and Therapy*, *41*, 1325–1335. doi:10.1016/S0005-7967(03)00039-1
Bardeen, J. R., & Read, J. P. (2010). Attentional control, trauma, and affect regulation: A preliminary investigation. *Traumatology*, *16*, 11–18. doi:10.1177/1534765610362801
Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzandoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, *133*, 1–24. doi:10.1037/0033-2909.133.1.1
Beck, J. G., Freeman, J. B., Shipherd, J. C., Hamblen, J. L., & Lackner, J. M. (2001). Specificity of Stroop interference in patients with pain and PTSD. *Journal of Abnormal Psychology*, *4*, 536–543. doi:10.1037/0021-843X.110.4.536
Bherer, L., Kramer, A. F., Peterson, M. S., Colcombe, S., Erickson, K., & Becic, E. (2008). Transfer effects in task-set cost and dual-task training in older and younger adults: further evidence for cognitive plasticity in attentional control in late adulthood. *Experimental Aging Research*, *34*, 188–219. doi:10.1080/03610730802070068
Bishop, S. J. (2008). Neural mechanisms underlying selective attention to threat. *Annals of the New York Academy of Sciences*, *1129*, 141–152. doi:10.1196/annals.1417.016
Blanchard, E. B., Jones-Alexander, J., Buckley, T. C., & Forneris, C. A. (1996). Psychometric properties of the PTSD Checklist (PCL). *Behavioral Research and Therapy*, *34*, 669–673. doi:10.1016/0005-7967(96)00033-2
Bouton, M. E. (2002). Context, ambiguity, and unlearning: Sources of relapse after behavioral extinction. *Biological Psychiatry*, *52*, 976–986. doi:10.1016/S0006-3223(02)01546-9
Bradley, B. P., Mogg, K., Millar, N., Bonham-Carter, C., Fergusson, E., Jenkins, J., et al. (1997). Attentional biases for emotional faces. *Cognition and Emotion*, *11*, 25–42. doi:10.1080/026999397380014
Bryant, R. A, & Harvey, A. G. (1997). Attentional bias in posttraumatic stress disorder. *Journal of Traumatic Stress*, *10*, 635–644. doi:10.1002/jts.2490100409
Buckley, T. C. (2000). Information processing in PTSD: A review of the empirical literature. *Clinical Psychology Review*, *28*, 1041–1065. doi:10.1016/S0272-7358(99)00030-36
Buckley, T. C., Galovski, T., Blanchard, E. B., & Hickling, E. J. (2003). Is the emotional stroop paradigm sensitive to malingering? A between-groups study with professional actors and actual trauma survivors. *Journal of Traumatic Stress*, *16*, 59–66. doi:10.1023/A:1022063412056
Compton, J. R. (2000). Ability to disengage attention predicts negative affect. *Cognition and Emotion*, *14*, 401–415. doi:10.1080/026999300378897
Constans, J. I. (2005). Information-processing bias in PTSD. In: J. J. Vasterling, & C. R. Brewin (Eds.), *Neuropsychology of PTSD: Biological, cognitive, and clinical perspectives* (pp. 105–130). New York: The Guilford Press.
Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed behavior and stimulus-driven attention in the brain. *Nature Reviews Neuroscience*, *3*, 201–215. doi:10.1038/nrn755
Derryberry, D., & Reed, M. A. (2002). Anxiety-related attentional biases and their regulation by attentional control. *Journal of Abnormal Psychology*, *111*, 225–236. doi:10.1037//0021-843X.111.2.225
Eisenberg, N., Fabes, R. A., Guthrie, I. K., & Reiser, M. (2000). Dispositional emotionality and regulation: Their role in predicting quality of social functioning. *Journal of Personality Social Psychology*, *78*, 136–157. doi:10.1037//0022-3514.66.4.776
Elzinga, B. M., & Bremner, J. D. (2002). Are the neural substrates of memory the final common Pathway in posttraumatic stress disorder (PTSD)? *Journal of Affective Disorders*, *70*, 1–17. doi:10.1016/S0165-0327(01)00351-2
Erk, S., Kiefer, M., Grothe, J., Wunderlich, A. P., Spitzer, M., & Walter, H. (2003). Emotional context modulates subsequent memory effect. *NeuroImage*, *18*, 439–447. doi:10.1016/S1053-8119(02)00015-0
Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion*, *7*, 336–353. doi:10.1037/1528-3542.7.2.336
Fan, J., McCandliss, B. D., Sommer, T., Raz, M., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, *14*, 340–347. doi:10.1162/089892902317361886
First, M. B., Spitzer, R. L., Gibbon, M., & Williams, J. B. W. (1994). *Structured Clinical Interview for Axis I DSM-IV Disorders—Patient Edition (SCID-I/P, Version 2.0)*. New York: Biometrics Research Department, New York State Psychiatric Institute.
Foa, E. B., Huppert, J. D., & Cahill, S. P. (2006). Emotional processing theory: An update. In: B. O. Rothbaum (Ed.), *Pathological anxiety Emotional processing in etiology and treatment* (pp. 3–24). New York: Guilford.
Foa, E. B., & Kozak, M. J. (1986). Emotional processing of fear: Exposure to corrective information. *Psychological Bulletin*, *99*, 20–35. doi:10.1037//0033-2909.99.1.20
Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion*, *16*, 355–379. doi:10.1080/02699930143000527
Frewen, P. A, Dozois, D. J. A., Joanisse, M. F., & Neufeld, R. W. J. (2008). Selective attention to threat versus reward: Meta-analysis and neural-network modeling of the dot-probe task. *Clinical Psychology Review*, *28*, 307–337. doi:10.1016/j.cpr.2007.05.006
Graydon, J., & Eysenck, M. W. (1989). Distraction and cognitive performance. *European Journal of Cognitive Psychology*, *1*, 161–179. doi:10.1080/09541448908403078
Gyurak, A., & Ayduk, O. (2007). Defensive physiological reactions to rejection: The effect of self-esteem and attentional control on startle responses. *Physiological Science*, *18*, 886–892. doi:10.1111/j.1467-9280.2007.01996.x
Harman, C., Rothbart, M. K., & Posner, M. I. (1997). Distress and attention interactions in early infancy. *Motivation and Emotion*, *21*, 27–43.
Ishigami, Y., & Klein, R. (2010). Repeated measurement of the components of attention using two versions of the Attention Network Test (ANT): Stability, isolability, robustness, and reliability. *Journal of Neuroscience Methods*, *190*, 117–128. doi:10.1016/j.jneumeth.2010.04.019
Jarvis, B. G. (2006). *DirectRT (Version 2006.1) [computer software]*. New York, NY: Empirisoft Corporation.
Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness training modifies subsystems of attention. *Cognitive, Affective, & Behavioral Neuroscience*, *7*, 109–119. doi:10.3758/CABN.7.2.109
Johnstone, K. A., & Page, A. C. (2004). Attention to phobic stimuli during exposure: The effect of distraction on anxiety reduction, self-efficacy and perceived control. *Behaviour Research and Therapy*, *42*, 249–275. doi:10.1016/S0005-7967(03)00137-2
Kimble, M. O., Frueh, B. C., & Marks, L. (2009). Does the modified Stroop effect exist in PTSD? Evidence from dissertation abstracts and the peer reviewed literature. *Journal of Anxiety Disorders*, *23*, 650–655. doi:10.1016/j.janxdis.2009.02.002
Kubany, E. S., Haynes, S. N., Leisen, M. B., Owens, J. A., Kaplan, A. S., Watson, S. B., et al. (2000). Development and preliminary validation of a brief broad-spectrum measure of trauma exposure: The Traumatic Life Events Questionnaire. *Psychological Assessment*, *12*, 210–224. doi:10.1037//1040-3590.I2.2.210
Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1999). *International affective picture system (IAPS) technical manual and affective ratings*. Gainesville, FL: The Center for Research in Psychophysiology, University of Florida.
Lavie, N., Hirst, A., de Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology: General*, *133*, 339–354. doi:10.1037/0096-3445.133.3.339
Litz, B. T., Weathers, F. W., Monaco, V., Herman, D. S., Wulfsohn, M., Marx, B., et al. (1996). Attention, arousal, and memory in posttraumatic stress disorder. *Journal of Traumatic Stress*, *9*, 497–520. doi:10.1007/BF02103661
MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology*, *95*, 15–20. doi:10.1037//0021-843X.95.1.15
Matthews, A., Yiend, J., & Lawrence, A. D. (2004). Individual differences in the modulation of fear-related brain activation by attentional control. *Journal of Cognitive Neuroscience*, *16*, 1683–1694. doi:10.1162/0898929042947810
McKenna, F. P., & Sharma, D. (2004). Reversing the emotional Stroop effect reveals that it is not what it seems: The role of fast and slow components. *Journal of Experimental Psychology*, *30*, 382–392. doi:10.1037/0278-7393.30.2.382
McNally, R. J. (1998). Experimental approaches to cognitive abnormality in posttraumatic stress disorder. *Clinical Psychology Review*, *18*, 971–982. doi:10.1016/S0272-7358(98)00036-1
McNally, R. J. (2007). Mechanisms of exposure therapy: How neuroscience can improve psychological treatments for anxiety disorders. *Clinical Psychology Review*, *27*, 750–759. doi:10.1016/j.cpr.2007.01.003
McNally, R. J., Amir, N., & Lipke, H. J. (1996). Subliminal processing of threat cues in posttraumatic stress disorder? *Journal of Anxiety Disorders*, *10*, 115–128. doi:10.1016/0887-6185(95)00040-2
McNally, R. J., Kaspi, S. P., Riemann, B. C., & Zeitlin, S. B. (1990). Selective processing of threat cues in posttraumatic stress disorder. *Journal of Abnormal Psychology*, *99*, 398–402. doi:10.1037//0021-843X.99.4.398
Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: Dynamics of willpower. *Psychological Review*, *106*, 3–18. doi:10.1037//0033-295X.106.1.3
Myers, K. M., & Davis, M. (2002). Behavioral and neural analysis of extinction. *Neuron*, *36*, 567–584. doi:10.1016/S0896-6273(02)01064-4
Nolen-Hoeksema, S., & Morrow, J. (1993). Effects of rumination and distraction on naturally occurring depressed mood. *Cognition & Emotion*, *7*, 561–570. doi:10.1080/02699939308409206
Norris, F., Foster, J., & Weisshaar, D. (2002). The epidemiology of sex differences in PTSD across developmental, societal and research contexts. In: R. Kimerling, P. Oimette, & J. Wolfe (Eds.), *Gender and PTSD* (pp. 3–42). New York: Guilford Press.
Orme, B. (2005). *SSI Web v5. Software for web interviewing and conjoint analysis*. Sequin, WA: Sawtooth Software, Inc.

Phaf, R. H., & Kan, K. J. (2007). The automaticity of emotional Stroop: A meta-analysis. *Journal of Behavior Therapy*, *38*, 184–199. doi:10.1016/j.jbtep.2006.10.008

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 Therapy*, *47*, 1050–1057. doi:10.1016/j.brat.2009.08.001

Pineles, S. L., Shipherd, J. C., Welch, L. P., & Yovel, I. (2007). The role of attentional biases in PTSD: Is it interference or facilitation? *Behaviour Research and Therapy*, *45*, 1903–1913. doi:10.1016/j.brat.2006.08.021

Pretz, J. E., Totz, K. S., & Kaufman, S. B. (2010). The effects of mood, cognitive style, and cognitive ability on implicit learning. *Learning and Individual Differences*, *3*, 215–219. doi:10.1016/j.lindif.2009.12.003

Redick, T. S, & Engle, R. W. (2006). Working memory capacity and Attention Network Test performance. *Applied Cognitive Psychology*, *20*, 713–721. doi:10.1002/acp.1224

Ruggiero, K. J., Del Ben, K., Scotti, J. R., & Rabalais, A. E. (2003). Psychometric properties of PTSD Checklist-Civilian Version. *Journal of Traumatic Stress*, *16*, 495–502. doi:10.1023/A:11025714729117

Salemink, E., van den Hout, M. A., & Kindt, M. (2007). Selective attention and threat: quick orienting and two versions of the dot-probe task. *Behaviour Research and Therapy*, *45*, 607–615. doi:10.1016/j.brat.2006.04.004

Schmidt, N. B., Richey, J. A., Buckner, J. D., & Timpano, K. R. (2009). Attention training for generalized social anxiety disorder. *Journal of Abnormal Psychology*, *188*, 5–14. doi:10.1037/a0013643

Spielberger, C. D. (1983). *Manual of the State-Trait Anxiety Inventory Form Y*. Palo Alto, CA: Consulting Psychologists Press.

Tolin, D. F., & Foa, E. B. (2006). Sex differences in trauma and posttraumatic stress disorder: A quantitative review of 25 years of research. *Psychological Bulletin*, *132*, 959–992. doi:10.1037/0033-2909.132.6.959

Weathers, F. W., Huska, J. A., & Keane, T. M. (1991). *PCL-C for DSM-IV*. Boston: National Center for PTSD-Behavioral Science Division.

Weathers, F. W., Keane, T. M., & Davidson, J. R. T. (2001). Clinician-Administered PTSD Scale: A review of the first ten years of research. *Depression and Anxiety*, *156*, 132–156. doi:10.1002/da.1029

Weathers, F. W., Litz, B. T., Herman, D. S., Huska, J. A., & Keane, T. M. (1993). The PTSD Checklist (PCL): Reliability, validity, and diagnostic utility. *Paper presented at the meeting of the International Society for Traumatic Stress Studies*. San Antonio, TX, October.

Weierich, M. R., Treat, T. A., & Hollingworth, A. (2008). Theories and measurement of visual attentional processing in anxiety. *Cognition & Emotion*, *22*, 985–1018. doi:10.1080/02699930701597601

Yiend, J. (2010). The effects of emotion on attention: A review of attentional processing of emotional information. *Cognition & Emotion*, *24*, 3–47. doi:10.1080/02699930903205698