



Threat modulation of visual search efficiency in PTSD: A comparison of distinct stimulus categories



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ABSTRACT

Although an attentional bias for threat has been implicated in posttraumatic stress disorder (PTSD), the cues that best facilitate this bias are unclear. Some studies utilize images and others utilize facial expressions that communicate threat. However, the comparability of these two types of stimuli in PTSD is unclear. The present study contrasted the effects of images and expressions with the same valence on visual search among veterans with PTSD and controls. Overall, PTSD patients had slower visual search speed than controls. Images caused greater disruption in visual search than expressions, and emotional content modulated this effect with larger differences between images and expressions arising for more negatively valenced stimuli. However, this effect was not observed with the maximum number of items in the search array. Differences in visual search speed by images and expressions significantly varied between PTSD patients and controls for only anger and at the moderate level of task difficulty. Specifically, visual search speed did not significantly differ between PTSD patients and controls when exposed to angry expressions. However, PTSD patients displayed significantly slower visual search than controls when exposed to anger images. The implications of these findings for better understanding emotion modulated attention in PTSD are discussed.

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1. Introduction

Posttraumatic stress disorder (PTSD) is a debilitating psychiatric condition that develops after exposure to a traumatic event (American Psychiatric Association [APA], 2013). PTSD may manifest in symptoms of re-experiencing, avoidance, negative changes in beliefs and feelings, and hyperarousal. These symptoms cause significant distress and often contribute to a poor quality of life (Olatunji et al., 2007). Recent efforts to improve the available psychological treatments for PTSD have increasingly focused on specific underlying cognitive processes (Schoorl et al., 2013). One core process that has been highlighted in integrative theories of PTSD is attention biases to threat-related cues (Brewin et al., 1996). Indeed, a propensity to locate and dwell on such cues may sustain hyperarousal and increase re-experiencing symptoms. Consistent with this view, experimental research has shown that individuals with PTSD preferentially allocate attentional resources toward threat-related cues (see Buckley et al., 2000 for review). Evidence for these biases has largely emerged from modified Stroop tasks. A recent review of this literature found that PTSD-relevant words impaired Stroop performance more among PTSD groups and

trauma exposed control participants compared to non-trauma exposed control participants (Cisler et al., 2011). PTSD groups and trauma exposed control participants did not differ. When examining within-subject effect sizes, PTSD-relevant words and generally threatening words impaired performance relative to neutral words among PTSD groups, and only PTSD-relevant words impaired performance among the trauma exposed control participants.

According to Fani et al. (2012), attention biases to threat-relevant cues are highly maladaptive and preclude adequate processing of corrective information in PTSD. Although findings from studies using the modified Stroop task are largely consistent with this view, the Stroop is limited in its ability to measure attention biases, i.e., facilitated orientation toward or avoidance of threat cues (Algom et al., 2004). The dot probe task has been employed as a more precise and adaptable measure for examining attention biases for threat in PTSD (Bryant and 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 attentional vigilance for threat. However, findings from studies using this task have been mixed with regard to direction or type of bias (e.g., whether it is facilitated orientation to or delayed disengagement from threat cues). Furthermore, research using visual search tasks in PTSD suggest that the attentional bias that is

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commonly observed may reflect difficulty disengaging from threat rather than attentional facilitation to threat-relevant cues (Pineles et al., 2007, 2009).

Although there have been significant advances in the sensitivity of the tasks used to more clearly delineate the nature of attentional biases for threat in PTSD, much less consideration has been given to the nature of the stimuli used to depict threat in these tasks. In some studies, 'threat' is represented by facial expressions of fear (Armstrong et al., 2013). For example, Fani et al. (2012) employed a dot probe task using facial expression pairs in which one expression in each pair displayed an emotional expression that was either threatening or happy, and the other displayed a neutral expression. The findings showed that participants with PTSD demonstrated increased activation in the dorsolateral prefrontal cortex in response to threat cue trials compared to controls. Other investigations have used images to represent threat (Kimble et al., 2010; Thomas et al., 2013). For example, Bardeen and Orcutt (2011) employed a dot probe task where two images, one neutral and one threat-related (e.g., man with knife, vicious dog), are presented simultaneously. The results indicated that higher PTSD symptoms were associated with attentional threat bias when stimulus-onset asynchrony was longer (i.e., 500 ms), suggesting difficulty disengaging from threat stimuli. Additionally, attentional control moderated the relationship between PTSD symptoms and attentional threat bias when stimulus-onset asynchrony was shorter (i.e., 150 ms), with participants high in PTSD symptoms and high in attentional control having disengaged and shifted attention from threat stimuli when the emotional valence of threat stimuli was less salient (i.e., shorter presentation duration). Attentional control refers to an individual's capacity to choose what they pay attention to and what they ignore. Although this study is consistent with recent research indicating that individual differences in attentional control may play an important role in attentional bias for threat observed in PTSD (Schoorl et al., 2014), the extent to which studies employing threatening facial expressions can be meaningfully compared with those employing threatening images to assess attentional biases for threat in PTSD remains unclear.

There is some overlap in brain regions that respond to threat-relevant images and facial expressions (Zald, 2003), suggesting that threatening facial expressions and images may be used interchangeably in research on attentional bias in PTSD. However, the brain regions do not overlap entirely (Andrews, 2005), and there are brain regions that specifically respond to features of images, such as shape, which may provide an indicator of threat during image processing, but not during facial expression processing (Bar and Neta, 2007). It is also important to note that the common use of the term "threatening" to describe negatively valenced expressions may be problematic given that fear and disgust expressions do not necessarily represent a threat. In fact, a fearful expression looking at you could mean the person is afraid of you. The extent to which the magnitude of emotional responding varies between fear and disgust images and fear and disgust expressions was addressed in one study using functional magnetic resonance imaging (Schafer et al., 2005). During passive viewing of threatening facial expressions and threatening images, disgust-evoking images resulted in activation in the amygdala, insula, and orbitofrontal cortex (OFC), whereas fear-relevant images were associated with activity in the insula, OFC, and middle temporal gyri. This finding suggests that exposure to disgust-evoking images and fear-relevant images may evoke different affective experiences given the distinct neural substrates. Importantly, exposure to facial expressions of disgust and fear did not yield significant activation in any brain regions. In a naturalistic environment where multiple stimuli may be in competition for attention, threatening expressions may lack the salience to capture attention

when threatening objects are also present. Although this suggests that use of threatening images may be ideal in better assessing attentional biases, there is a paucity of research examining how threatening images and threatening expressions differentially influence attentional processing, as well as their concordance across different emotions in PTSD.

The purpose of the present investigation was to examine the differential effects of exposure to threatening images and threatening expressions on visual search speed in PTSD. Several tasks of attention, including the Stroop and dot-probe, have been used in the PTSD literature. In such tasks, the emotional distraction is overlapping or preceding a target selection process by a short time interval. In contrast, the present study employs a visual search task that requires multiple shifts of attention. The task takes more than a second to be completed and is likely to be a closer approximation of the complex demands on attention in daily life. Previous research suggests that visual search reaction time for some stimuli increases as the number of distractors increases (Carrasco and Yeshurun, 1998). This effect may be attributed to limited covert attentional processes and recent research has shown that the emotional significance of distractor stimuli may be increasingly less accessible from working memory when engaging in more complex visual search (Olatunji et al., *In press*). The limited covert attentional processes that may be attributed to increasing the number of distractors during tasks of visual search is relevant to better understanding PTSD-related phenomena as recent research suggests that a low ability to control attention may be a risk factor for the disorder (Bardeen and Orcutt, 2011; Schoorl et al., 2014). Furthermore, it is unclear how emotional distractors influence the speed of those with PTSD during visual search tasks with increasing levels of complexity. Accordingly, the present study also examines how use of three different array sizes influence the ability to redirect attention after exposure to images relative to facial expressions.

Given the complexity of images relative to facial expressions, it was predicted that exposure to images would result in greater attentional capture, thus resulting in greater disruption in visual search speed compared to facial expressions. More critically, we predicted that the emotional content of stimuli (threat vs. non-threat) would differentially impact visual search performance among those with PTSD (compared to controls). Specifically, it was predicted that exposure to threatening images would result in greater impairment in target detection relative to exposure to non-threatening images among those with PTSD (compared to controls). Similarly, it was predicted that exposure to threatening expressions would result in greater impairment in target detection relative to exposure to non-threatening expressions among those with PTSD (compared to controls). Such a hypothesis would be consistent with attentional capture paradigms that show that highly arousing stimuli impair the ability to detect targets for several ms after an emotional stimulus has captured attention (McHugo et al., 2013). Given that threatening images are generally perceived as having higher subjective intensity and more arousing features than expressions (Britton et al., 2006), it was also predicted that the difference between images and facial expressions in visual search speed would be greater for negative arousing stimuli (fear, anger, disgust) relative to neutral or happy stimuli, especially among those with PTSD (compared to controls).

2. Method

2.1. Participants

Participants were 21 veterans who met diagnostic criteria for PTSD and 22 non-veteran controls (NCC) with no current

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