The Regulatory Role of Attention in PTSD from an Information Processing Perspective

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Attentional deployment is one of the primary regulation strategies discussed in prominent information processing models of emotion regulation. Despite its theoretical relevance to emotion regulation, attentional deployment has received relatively little focus in the emotion regulation literature compared to regulatory strategies that occur later in the emotion generative process. It may be especially important to consider the regulatory role of attentional deployment in the pathogenesis of posttraumatic stress disorder (PTSD) because hypervigilance toward threatening information is a hallmark symptom of the disorder and attentional bias to threat has been suggested as a factor contributing to the development and maintenance of PTSD. In examining the regulatory role of attentional deployment in PTSD, it was first necessary to discuss information processing models of PTSD and review the extant literature in the area of PTSD-related attentional biases. Discrepancies in this literature may be the result of failing to consider the role that effortful attentional deployment plays in regulating emotional distress. The relevance of attentional deployment to recent attention-related clinical interventions for PTSD is also discussed.

Keywords: attentional deployment, attentional control, attentional bias, emotion regulation, trauma, posttraumatic stress disorder, PTSD, information processing, attention bias modification.
CHAPTER STARTS HERE

Introduction: Overview of attentional deployment as a form of emotion regulation

Information processing models of emotion regulation suggest that the ability to deploy attention in the service of altering one’s emotional experience (i.e., attentional deployment, also described as attentional control) is essential for maintaining psychological well-being (Gross, 1998). Moreover, threat-related attentional impairments predict general emotion dysregulation and increased use of maladaptive emotion regulation strategies (Bardeen & Daniel, 2017a; Bardeen, Daniel, Hinnant, & Orcutt, 2017). In Gross’s (2015) process model of emotion regulation, attentional deployment is one of five points in the emotion generative process at which emotions can be regulated. The four other points in Gross’s (2015) model include situation selection, situation modification, cognitive change, and response modulation (Gross & Thompson, 2007). Of these points in the emotion generative process, cognitive change (e.g., cognitive reappraisal) and response modulation (e.g., expressive suppression) have received considerable attention in the extant literature while regulatory processes occurring earlier in the temporal chain, such as attentional deployment, have received relatively little consideration. This is unfortunate because these earlier processes are thought to require less cognitive resources to enact, and thus, may be more easily altered through psychological intervention (Renna et al., 2018).

Attentional control is distinct from other regulation strategies in that it is present from infancy onward (Rothbart, Sheese, & Posner, 2006). For example, children who disengage and shift their attention from appetitive stimuli (e.g., candy) are more successful at delaying gratification (Mischel, Shoda, & Rodriguez, 1989). The beneficial effects of attentional control have been trumpeted in the extant literature because evidence from a number of studies suggests
that attentional control protects those who are vulnerable to maladaptive psychological outcomes, such as posttraumatic stress (Bardeen, Fergus, & Orcutt, 2015), from experiencing such outcomes (Fergus, Bardeen, & Orcutt, 2012; Jones, Fazio, & Vasey, 2012; Richey, Keough, & Schmidt, 2012).

It may be especially important to consider the regulatory role of attentional deployment in the pathogenesis of posttraumatic stress disorder (PTSD) because attention-related abnormalities and deficits have been observed among those with PTSD (Scott et al., 2015). Moreover, hypervigilance toward threatening information is a hallmark symptom of the disorder (Diagnostic and Statistical Manual of Mental Disorders [DSM-5]; American Psychiatric Association [APA], 2013). Because hypervigilance is a hallmark symptom of PTSD, there has been an emphasis on understanding the attentional processing of threat- and trauma-related information among those with PTSD, with the idea that hypervigilance and facilitated threat detection are synonymous. Following from this logic, individuals with PTSD (versus those without) should preferentially process threat- and trauma-related stimuli (i.e., attentional bias to threat [ABT]), and according to theory, this ABT should promote the development and maintenance of PTSD symptoms (e.g., Beck, Emery, & Greenberg, 1985; Williams, Watts, MacLeod, & Matthews, 1997). Specifically, prolonged attentional engagement with threat information is thought to result in protracted states of distress that decrease the cognitive resources that are available for the emotional processing of threat- and trauma-related information (Foa & Kozak, 1986), thus resulting in the development and/or maintenance of PTSD symptoms.

Findings regarding the degree to which individuals with PTSD exhibit ABT have been mixed, with some suggesting that PTSD-related ABT is a robust phenomenon (e.g., Buckley,
Galovski, Blanchard, & Hickling, 2003; Constans, 2005), and other work suggesting that the results used to support PTSD-related ABT are weak at best. In fact, a considerable number of null findings have been reported and failure to replicate significant findings is fairly common in this literature (e.g., Kimble, Frueh, & Marks, 2009; Van Bockstaele et al., 2014). Discrepancies in the extant literature may be the result of failing to consider the role that top-down attentional processes (i.e., controlled, effortful, and goal-directed) play in regulating bottom-up reactivity (i.e., sensory driven, automatic).

**Information Processing in PTSD: The Fear Network**

Information processing models of PTSD were developed from a framework consistent with a classic cognitive network model of memory. Specifically, the network (a “fear network”) is made up of interconnected representations of trauma-related memories. Emotional processing theory (Foa & Kozak, 1986), the most prominent information processing theory of PTSD, presupposes automatic threat processing. In this model, a network of interconnected trauma memory nodes is hypothesized to be linked by a process of spreading activation. Memory nodes represent a variety of features related to a traumatic event (e.g., stimulus information, physiological and emotional reactions, response information; Foa, Huppert, & Cahill, 2006; Foa & Kozak, 1986). 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 of PTSD. Moreover, repeated activation of the network is thought to increase autonomic fear responses, which in turn results in a state of hypervigilance and the preferential processing of threat-relevant stimuli (i.e., facilitated engagement).
Unlike emotional processing theory (Foa & Kozak, 1986), which implies that there is a single representation of a traumatic event in one’s memory, dual-representation theory proposes a model in which traumatic memories are encoded in two systems (Brewin, Dalgleish, & Joseph, 1996). Although these systems typically act in parallel, one system may take precedence over the other. In the “verbally accessible memory” (VAM) system, memories are stored in narrative form and are integrated into the larger narrative of one’s history (Brewin et al., 1996). These are memories that can be retrieved through active efforts because they contain information that the individual has consciously processed and stored in long-term memory. In contrast, the “situationally accessible memory” (SAM) system contains information that may not have been processed using higher-level perceptual processes (Brewin et al., 1996). The SAM system does not use verbal narratives; memories are stored as a collection of sights, sounds, smells, bodily sensations, etc. Because SAM system memories have not been consciously processed, the individual does not have voluntary control over their conscious retrieval. Thus, the SAM system is associated with processes that seem to be reflexive, or more automatic, such as trauma reexperiencing (e.g., flashbacks) and bodily sensations experienced at the time of the traumatic event (i.e., autonomic nervous system arousal, hypervigilance). According to Brewin et al. (1996), it is necessary to integrate SAM system memories into the VAM system in order for one to recover from PTSD.

Ehlers and Clark (2000) proposed a similar two-system model in which trauma memories are poorly integrated into an autobiographical memory system among individuals with PTSD. The autobiographical memory system is similar to Brewin et al.’s (1996) VAM system. Ehlers and Clark (2000) also proposed an associative memory system, similar to Brewin et al.’s (1996) SAM system, in which information is processed preconsciously. The associative memory system
is sensory driven and primes the individual to automatically react to trauma reminders when threat stimuli are present. Although these multi-system models are very similar, Ehlers and Clark (2000) suggested that the encoding of information in the associative memory system at the time of the traumatic event is a risk factor for the development of PTSD, whereas dual-representation theory (Brewin et al., 1996) suggests that SAM system encoding of trauma information is only harmful if SAM system encoding greatly outweighs VAM system encoding (Brewin & Holmes, 2003). Additionally, Ehlers and Clark’s (2000) cognitive model of PTSD is more complex, placing greater emphasis, and providing more conceptual detail, on the appraisal of trauma sequelae and maladaptive cognitive and behavioral coping strategies.

The fear network model presented in emotional processing theory 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 et al., 2006). However, 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 (i.e., inhibitory learning; Craske, Treanor, Conway, Zbozinek, & Vervilet, 2014; Knowles & Olatunji, 2018; McNally, 2007). Thus, recovery from PTSD may occur through the creation of new associations in the network that inhibit previously dominant pathways. Although the single level of representation proposed in emotional processing theory has provided us with an important conceptualization of bottom-up threat processing in PTSD (Foa & Kozak, 1986), it does not account for the regulation of bottom-up reactivity through the use of top-down resources. As such, multiple representation models such as dual-representation theory (Brewin et al., 1996) and Ehlers and Clark’s (2000) cognitive
model, which account for bottom-up and top-down processing, may provide a more accurate conceptualization of the processing of trauma- and threat-information.

Cognitive network conceptualizations of PTSD provide a framework from which to understand the role of attentional processes and their influence on threat processing in PTSD. Much like network models of PTSD, conceptualizations of ABT in PTSD vary in the degree to which bottom-up and top-down processing are emphasized. Bottom-up processing is emphasized in a number of theories (e.g., Beck & Clark, 1997, Litz & Keane, 1989, Williams, Watts, MacLeod, & Matthews, 1997), while dual-process models of threat processing in PTSD assert that two systems (bottom-up and top-down) interact to differentially impact the expression of threat biases (e.g., Corbetta & Shulman, 2002; Eysenck & Derakshan, 2011).

**Attentional Bias to Threat: Bottom-up, Top-down, or Both?**

The majority of theories that describe the etiology of fear-related pathology, including PTSD, implicate ABT in the development and maintenance of these pathological presentations (Weierich, Treat, & Hollingsworth, 2008). ABT is most often conceptualized as being reflexive, automatic, and occurring outside of conscious awareness (Constans, 2005; Yiend, 2010). This conceptualization suggests that individuals with relatively higher levels of anxiety/fear exhibit faster detection of threat stimuli (i.e., facilitated engagement). Although faster detection of threat may be extremely beneficial in some contexts (e.g., identifying weapons in a combat zone), repeated and prolonged attention toward stimuli that are objectively safe (e.g., weapons in movies, magazines, etc.) is thought to maintain hyperarousal and negative affective states, resulting in greater functional impairment and increased vulnerability for the development of fear-related pathology (Constans, 2005).
ABT has also been defined more broadly (e.g., “differential attentional allocation towards threatening stimuli relative to neutral stimuli,” Cisler & Koster, 2010). This type of definition does not presuppose facilitated engagement as the attentional process through which individuals with higher levels of anxiety/fear attend to threat stimuli for a greater duration of time. Instead, it allows for the possibility that other attentional processes may account for prolonged attention to threat (i.e., deficits in strategic processing which result in difficulty disengaging from threat stimuli). In other words, this type of definition accounts for automatic (i.e., capacity-free processing occurring without awareness) and strategic information processing (i.e., limited capacity, controllable, implies awareness).

**Vigilance-avoidance Versus Attention Maintenance**

Two seemingly contradictory hypotheses are frequently cited to explain evidence of fear-related ABT: vigilance-avoidance and attention maintenance. The vigilance-avoidance hypothesis of ABT presupposes reflexive orienting of attention toward threat (i.e., facilitated engagement), which in turn, increases sympathetic nervous system arousal and facilitates rapid responding. According to this hypothesis, following initial facilitated detection, fearful individuals quickly shift attention away from threat stimuli to reduce negative affect and the physiological arousal that is provoked by initially attending to the stimulus (i.e., avoidance). Habitually disengaging and shifting attention from threat is considered a maladaptive avoidance strategy that may alleviate physiological and emotional distress in the short-term, but may maintain trauma-related fear and PTSD symptoms over time by failing to provide the opportunity for new learning. The prominence of the vigilance-avoidance hypothesis in the ABT-PTSD literature (compared to the attention maintenance hypothesis) may be a function of
its intuitive appeal, as hypervigilance for, and avoidance of, trauma-related stimuli are central to the symptom profile of PSTD (*DSM-5*; APA, 2013).

In contrast to the vigilance-avoidance hypothesis, the attention maintenance hypothesis does not presuppose faster orienting toward threat stimuli; instead, once threat stimuli are identified, it is more difficult for the fearful individual to disengage and shift attention away from such stimuli (Weierich et al., 2008). Thus, the mechanism underlying ABT is not facilitated engagement (i.e., bottom-up), but difficulty disengaging from threat stimuli due to a relative deficit in the ability to regulate attention deployment (i.e., top-down). Further, according to the attention maintenance hypothesis, prolonged emotional distress and the subsequent development of fear-related pathology is thought to be a function of prolonged attending to threat stimuli. This hypothesis is consistent with evidence that prolonged attentional engagement with perceived threat, due to disengagement difficulties, maintains negative affective states (Bardeen & Read, 2010; Compton, 2000).

At first glance, these two hypotheses appear incompatible. The vigilance-avoidance hypothesis explains ABT by focusing on individual differences in bottom-up reactivity, whereas the attention maintenance hypothesis emphasizes deficits in top-down regulatory abilities as the mechanism by which differences in ABT are observed. The apparent discrepancy between these two hypotheses appears to be a function of focusing on only one of the two primary attentional streams (i.e., bottom-up or top-down) in conceptualizing ABT rather than considering that these two systems may both contribute to ABT.

**Dual-process Models of ABT: Considering the Role of Attentional Control**

In contrast to theories that focus on one specific attentional system in accounting for ABT, dual-process theories consider the combined influence of bottom-up and top-down
attentional systems on ABT. More specifically, dual-process theories of ABT suggest that anxiety/fear potentiate the bottom-up system, increasing the likelihood that those with higher levels of anxiety/fear will identify potential threat stimuli quicker than those with relatively lower levels of anxiety/fear (Corbetta & Shulman, 2002; Eysenck et al., 2007; 2011; Metcalfe & Mischel, 1999). Additionally, anxiety/fear simultaneously reduce one’s ability to use top-down attentional control to decrease the impact of this bottom-up reactivity. Corbetta and Shulman (2002) hypothesized that the bottom-up system is stimulus-driven, designed for rapid responding to salient and self-relevant stimuli, whereas the top-down system is influenced by current goals, knowledge, and expectations. Similarly, Metcalfe and Mischel (1999) hypothesized that the bottom-up system (i.e., the “hot” system) is specialized for immediate responding, whereas the top-down system (i.e., the “cool” system) is specialized for reflective emotion regulation and control of impulsive tendencies (Metcalfe & Mischel, 1999).

Attentional control theory suggests that the balance between these two attentional systems is disrupted when high levels of anxiety/fear potentiate bottom-up reactivity and impair top-down attentional control (i.e., Eysenck et al., 2007; 2011). However, some evidence suggests that the potentiation of stimulus-driven attention among those with fear-related distress may be the result of enhanced bottom-up reactivity for salient or novel stimuli in general rather than being specific to stimuli that are trauma- or threat-related (Esterman et al., 2013; Sarapas, Weinberg, Langenecker, & Shankman, 2017). Individuals with PTSD may detect all salient cues more quickly because of the trauma-related perception that (a) the probability of threat being present is high, and (b) failing to detect threat quickly will result in a catastrophic outcome (i.e., probability overestimation; White, McManus, & Ehlers, 2008). These individuals may experience a state of tonic alertness that is conceptually consistent with PTSD-related
hypervigilance. Results showing that fear/anxiety-related bottom-up reactivity is stimulus non-specific are also consistent with the fear generalization that is observed among those with PTSD. Instead of trauma-specific fear and related avoidance, individuals with PTSD exhibit fear responding to, and avoidance of, contexts that are unpredictable and in response to stimuli that are seemingly unrelated to one’s traumatic event(s) (Dymond, Dunsmoor, Vervliet, Roche, & Hermans, 2015; Jovanovic & Ressler, 2010; Lissek, 2012).

To consider the role of attentional control, and whether or not it is impaired or dysregulated among those with higher levels of fear/anxiety, it may be important to break this construct down into its component parts. There are three primary cognitive processes that have been identified as central to attentional control: (a) inhibition of prepotent task-irrelevant stimuli and associated responses, (b) flexibly orienting attention toward task-relevant stimuli (i.e., shifting), and (c) updating working memory (Eysenck et al., 2007; Miyake, Friedman, Emerson, Witzki, & Howarter, 2000). In support of attentional control theory (Eysenck et al., 2007), anxiety/fear has been shown to impair the inhibition and shifting functions of attentional control (Graydon & Eysenck, 1989; Lavie, Hirst, de Fockert, & Viding, 2004). Thus, individuals in a heightened state of anxiety/fear will be less successful at tasks in which these attentional control processes are needed. Furthermore, when task-irrelevant stimuli (e.g., trauma-relevant stimuli) increase participant distress, these stimuli will be attended to for a greater length of time as a result of anxiety/fear’s detrimental influence on inhibition and shifting. Thus, deficits in attentional control processes that limit the ability of the individual to disengage attention from trauma- and threat-related stimuli may differentiate those who experience mild posttraumatic stress symptoms that remit in the acute aftermath of a traumatic event from those who go on to
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It is important to consider that the bottom-up influence of anxiety/fear on the stimulus-driven system can be reduced, and perhaps eliminated, among those with fear-related pathology by increasing effort, using more resources, or by limiting oneself to contexts in which trauma- and threat-stimuli are less salient (Eysenck & Derakshan, 2011). Specifically, among individuals with PTSD, those with relatively better attentional control may be able to disengage and shift attention from perceived threat by drawing on reserve attentional control resources through active effort, while those with relatively poorer attentional control abilities should theoretically have a more difficult time disengaging from threat stimuli because they lack the requisite resources to do so. Thus, while anxiety/fear impairs the inhibition and switching functions of attentional control, individuals who have an abundance of attentional control may still use this resource to regulate bottom-up reactivity. Environmental factors may make it more or less difficult to use attentional control in this manner.

It has been suggested that competition between bottom-up and top-down attentional systems is affected not only by one’s level of anxiety/fear, but also by factors such as the duration of exposure to the threat, threat saliency or intensity (stimulus valence), and competition with other stimuli for processing resources (Bishop, 2008). For example, among individuals with PTSD, those with relatively better (versus relatively worse) attentional control abilities may be able to use these abilities to down-regulate bottom-up reactivity when threat salience is at low to moderate levels. When threat salience is high (e.g., revisiting the site of the index trauma), however, the influence of fear on attentional control resources may be so intense that top-down regulation of bottom-up reactivity is improbable (e.g., disengaging and shifting attention from...
trauma-stimuli). Evidence from studies in which EEG and fMRI have been employed has shown that (a) anxiety/fear impairs prefrontal brain regions associated with attentional control and (b) this impairment can be reversed in individuals with greater anxiety/fear-related pathology to compensate for potential impairments in task demands by drawing on available top-down resources (Rosler, Heil, & Roder, 1997; Wager, Jonides, & Reading, 2004).

Some have suggested that the distinction between top-down and bottom-up threat processing (automatic versus controlled) is one that is rarely clear (Todd, Cunningham, Anderson, & Thompson, 2012; Verbruggen, 2016). The line between automatic and controlled threat processing is sometimes blurry because sensory systems may be “pre-tuned” so that specific categories of stimuli are preferentially processed in an attempt to modulate emotional distress (Todd et al., 2012), especially when the presence of trauma- and/or threat-cues are predictable. For example, a survivor of a traumatic car accident may predict the occurrence of the feared stimulus (e.g., a motor vehicle) in a given situation (e.g., grocery store parking lot). In preparation for exposure to the feared stimulus, the trauma survivor proactively reconfigures his or her bias settings (i.e., prioritizes the use of top-down attentional control) so that attention is quickly diverted from the feared stimulus to stimuli from a neutral category. This in turn results in the down-regulation of emotional distress in the short-term. This has been described elsewhere as a “prepared-reflex;” once proactive adjustments in top-down control have been made, the inhibitory response can be activated easily by relevant stimuli (Verbruggen, 2017).

In the above example, the ability to predict the presence of the feared stimulus is important; the trauma survivor would not be prepared to shift attention away from a feared stimulus that appears in an unusual context (e.g., a car parked on the roof of a house). However, the more frequently that one uses top-down attentional control to inhibit bottom-up reactivity, the
faster that inhibitory effect becomes (Koole, Webb, & Sheeran, 2015). Consistent with this proposition, evidence suggests that it takes as little as 150ms for top-down attentional processes to influence the processing of threat information (Bardeen & Orcutt, 2011; Shomstein, Kravitz, & Behrmann, 2012). In addition, bottom-up activation is more likely to trigger top-down inhibition in individuals with better developed attention control, with inhibition becoming an almost automatic response to bottom-up activation (Metcalf & Mischel, 1999). As such, use of attentional control as a trauma-related regulatory mechanism may become habitual, no longer requiring active deliberation after prolonged use of the once effortful strategy. In summary, among individuals with PTSD, those with relatively better attentional control and repeated experience employing this top-down resource to inhibit bottom-up reactivity, may be better able to disengage and shift attention from threat information than individuals with PTSD and poorly developed attentional control. Before we consider whether deploying attention away from threat stimuli in this manner is adaptive, let us first discuss commonly used methods of assessing ABT.

**Measuring ABT in PTSD**

Although a number of different stimulus-response paradigms have been used to assess PTSD-related ABT (e.g., rapid serial visual presentation [e.g., Olatunji, Armstrong, Mchugo, & Zald, 2013], visual search [e.g., Pineles, Shipherd, Mostoufi, Abramovitz, & Yovel, 2009]), the modified Stroop task has received the most attention in this literature. In the traditional Stroop task, participants view a list of words and are asked to name the color in which each word is printed as quickly as possible while ignoring the meaning of the word. This task becomes more difficult when the color of the ink differs from the meaning of the word (e.g., the word “blue” written in green ink). Similarly, in the version of the task that has been modified to assess ABT, participants are asked to name the color of a series of one-word stimuli as quickly as possible.
while paying no attention to the word’s meaning. Each word comes from a specific category (e.g., trauma, positive, neutral, etc.). Slower responding to specific word categories is thought to occur when attention is briefly captured by the potency of word meaning, thus disrupting the processing of color information.

Although some have suggested that the evidence of ABT among those with PTSD is “strong” and “abundant,” with the majority of studies examining PTSD-related ABT via the modified Stroop showing slowed responding of color naming trauma-relevant words among those with PTSD (Constans, 2005), a review of peer-reviewed journal articles and dissertation abstracts suggests otherwise. Specifically, Kimble et al. (2009) conducted a review of studies in which the modified Stroop task was used to examine ABT in trauma-exposed adults (with and without PTSD). Slowed responding to threat words among individuals with PTSD was only reported in 8% of dissertation abstracts and 44% of peer-reviewed journal articles. Before taking these results as evidence of an absence of ABT among those with PTSD, it is important to consider what the modified Stroop task actually measures. The task was originally developed to assess bottom-up facilitated engagement, but some evidence suggests that response times on the modified Stroop task represent individual differences in the top-down processing of threat information (McKenna & Sharma, 2004; Phaf & Kan, 2007; Weierich et al., 2008).

The modified Stroop task is typically presented in one of two formats: (a) a random format in which all word types are mixed together and presented at random, and a (b) blocked format in which each category of word stimuli is presented together. The blocked format provides a measure of the combined effect of the bottom-up and top-down components of attention, whereas the random format only provides a measure of bottom-up ABT (McKenna & Sharma, 2004). In the traditional Stroop paradigm, slowed responding occurs when there is a
conflict between two processes that are relatively automatic (i.e., word meaning and color naming). In contrast, in the modified Stroop task, color naming, a more automatic process, competes with the decoding of trauma and threat word meanings (Phaf & Kan, 2007). If the decoding of these words occurred at an automatic, preattentive level, then the modified Stroop task might be an appropriate measure of bottom-up ABT when the random format is employed. Contrary to the expectation of automaticity that the original task is founded on, evidence of the modified Stroop effect has only been observed when the blocked format has been used. This pattern of findings suggests that observed effects of PTSD-related ABT using this task are likely the result of differences in top-down attentional processes (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; McKenna & Sharma, 2004).

The dot-probe task is another stimulus-response task used to examine PTSD-related ABT (e.g., Bardeen & Orcutt, 2011; Bryant & Harvey, 1997; Iacoviello et al., 2014; Wald et al., 2011). At the beginning of each trial of the task, a fixation cross appears in the center of the screen and is then replaced by two stimuli presented side by side. The stimuli remain on the screen for a specified duration of time (e.g., typically a stimulus-onset asynchrony of 500ms) and then a dot appears on the screen, replacing one of the two pictures. To provide the researcher with a snapshot of the participant’s attention allocation at that point in time, the participant presses a button as quickly as possible that corresponds to the relative position of the dot on the screen. If the participant has a bias for attending to trauma or threat stimuli, s/he should respond faster when the dot appears in the spatial position previously held by these types of stimuli.

Among the studies in which this task has been used to examine PTSD-related ABT, design decisions have limited the degree to which study findings help to elucidate the nature of threat processing. Specifically, the dot-probe task can provide temporal snapshots of attention
allocation when multiple stimulus presentation durations are used. However, using multiple presentation durations requires substantially lengthening task duration, thus increasing concerns regarding the impact of participant fatigue on responding. As a result, in the large majority of studies in which the task has been employed, stimuli are typically only presented for 500ms (Bar-Haim et al., 2010; Bryant & Harvey, 1997; Elsesser, Satory, & Tackenberg, 2004; Fani et al., 2012; Iacoviello et al., 2014; Schafer et al., 2016; Sipos, Bar-Haim, Abend, Adler, & Bliese, 2014; Yuval, Zvielli, & Bernstein, 2017). This presentation duration allows for multiple shifts in attention (Mogg & Bradley, 1998), thus precluding inferences regarding the degree to which ABT, when it is observed, is primarily bottom-up, top-down, or a combination of the two.

Findings from dot-probe studies in which PTSD-related ABT is examined have been mixed. Differences between studies in dot-probe design and administration may account for some of the ambiguity of findings in this area of research. It is not only unclear from these findings whether those with PTSD exhibit ABT, but also whether PTSD-related abnormalities in threat processing (a) take the form of facilitated engagement, avoidance, or disengagement difficulties, (b) are observed across a variety of stimuli (i.e., word, face, images), (c) are trauma-specific or threat-general, and so on. For example, in one of the first studies to use the dot-probe to assess PTSD-related ABT, Bryant and Harvey (1997) found that participants with PTSD (versus those with subclinical PTSD or low anxiety) exhibited ABT for mild, but not strong threat words. Bryant and Harvey (1997) concluded that study findings suggested greater hypervigilance toward threat among individuals with PTSD (i.e., facilitated engagement); however, as described above, the use of a 500ms stimulus presentation duration precludes this conclusion. Additional modifications to the dot-probe task that was used in this study may have increased error variance and contributed to the unexpected finding of a PTSD-related bias to
“mild,” but not “strong” threat words. Some of these modifications include simultaneous presentation of word stimuli and response options and 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). In studies in which the same stimulus presentation duration used by Bryant and Harvey (1997) was employed (i.e., 500ms), support for PTSD-related ABT (i.e., faster responding when the dot replaces threat stimuli compared to neutral stimuli; Fani et al., 2012) and avoidance of threat stimuli among those with PTSD (i.e., faster responding when the dot replaced neutral stimuli compared to threat stimuli; Bar-Haim et al., 2010; Sipos et al., 2014) has been observed. In contrast to Bryant and Harvey (1997), Dalgleish et al. (2003) did not find ABT for threat words among participants with PTSD versus those with depression, generalized anxiety disorder, or with no diagnosis. Use of a relatively long presentation duration (1500ms) may explain these discrepant findings.

Despite the fact that ABT is conceptualized as a vulnerability factor for the development of fear-related pathology (Weierich et al., 2008), and PTSD more specifically (Constans, 2005), relatively few studies have been conducted to clarify the temporal relations among ABT, trauma, and PTSD. In fact, Van Bockstaele et al. (2014) identified the issue of temporality (i.e., ABT preceding the onset of fear-related pathology) as a “major gap in the current state of the literature.” Findings from the few longitudinal studies that have employed stimulus-response paradigms in this area are mixed. There is evidence in favor of both avoidance of threat (Wald et al., 2013) and general attention dysregulation (both toward and away from threat; Schafer et al., 2016) prospectively predicting higher posttraumatic symptoms. In contrast, some evidence suggests that ABT develops in response to trauma exposure rather than being a pre-trauma vulnerability factor (Iacoviello et al., 2014). These equivocal findings may be the result of the
same methodological limitations of stimulus-response paradigms (modified Stroop and dot-probe) described above.

Another potential limitation in this area of research, which may account for discrepant findings, is the use of traditional ABT scores that are calculated by aggregating task response times. Take the dot-probe task for example; ABT is typically calculated by subtracting mean response latencies on trials where the probe replaces the threat image from mean response latencies on trials where the probe replaces the neutral image in neutral-threat pairings (Frewen, Dozois, Joanisse, & Neufeld, 2008). Negative bias scores indicate greater attention deployment toward neutral stimuli and positive scores indicate attention deployment toward threat stimuli. Importantly, these difference scores represent ABT as a static signal (i.e., bias toward or away from threat at a constant rate over time), thus failing to take into account the temporal dynamics of ABT (i.e., a succession of shifts toward and away from threat stimuli; Zvielli, Bernstein, & Koster, 2015). Use of the traditional static method of calculating ABT may be responsible for (a) the notoriously poor reliability of these scores (Schmukle, 2005; Staugaard, & Rosenberg, 2011; Waechter, Nelson, Wright, Hyatt, & Oakman, 2014), (b) difficulty replicating significant findings (e.g., Fani, Tone, et al., 2012, and Fani, Jovanovic, et al., 2012), and (c) the considerable number of null findings and small magnitude effects in this area of research (Van Bockstaele et al., 2014).

To remedy these issues, response latencies from these same tasks can be used to calculate a score that represents threat-related attention dysregulation and accounts for within-subject variability of ABT, both toward and away from threat stimuli (i.e., attention bias variability; Zvielli et al., 2015). Although this method is relatively new, preliminary evidence suggests that individuals with PTSD exhibit significantly greater attention bias variability in response to
trauma-specific (Yuval et al., 2017) and general-threat (Bardeen, Tull, Daniel, Evenden, & Stevens, 2016; Iacoviello et al., 2014; Naim et al., 2015) stimuli compared to trauma control and healthy participants. Additionally, in contrast to the poor reliability observed for traditional attentional bias scores, acceptable reliability coefficients have been reported for attention bias variability scores (e.g., Schafer et al., 2016; Zvielli et al., 2015). However, this approach does not necessarily remedy all of the limitations of stimulus-response tasks. For example, the majority of these preliminary studies have employed the same stimulus presentation duration (i.e., 500ms) as the large majority of dot-probe studies described above. As described, use of this specific presentation duration allows one to shift attention multiple times before a response is made (Mogg & Bradley, 1998), and thus, inferences regarding bottom-up reflexive orienting cannot be made through the use of this approach.

Eye-tracking technology, which has a number of benefits over stimulus-response tasks for assessing PTSD-related ABT, has been used in relatively few studies in this line of research. Unlike stimulus-response tasks that use button press to make inferences about covert attention, with eye tracking, the construct of interest (overt attention) is directly assessed via eye movements. As such, eye-tracking indices are less susceptible to alternate explanations than attentional bias scores from stimulus-response tasks. Additionally, indices of attentional bias obtained via eye tracking (e.g., proportion of viewing time on threat vs. neutral stimuli) have been shown to have adequate reliability (Bardeen & Daniel, in press; Waechter et al., 2014). There is, however, one notable exception to this rule. To assess facilitated engagement, researchers often calculate a score that incorporates the participants’ first fixations to the stimuli that are presented (e.g., proportion of first fixations to threat versus neutral stimuli). These scores tend to have unacceptably low reliability (Waechter et al., 2014). Fortunately, unlike the covert
assessment of ABT at 500ms, overt assessment of ABT (via eye tracking) in the first 500ms of stimulus presentation has been identified as a valid measure of facilitated engagement (Armstrong & Olatunji, 2012), and importantly, exhibits significantly better reliability than attentional bias scores from stimulus-response paradigms (e.g., Bardeen & Daniel, in press). In addition to producing indices of ABT that have adequate reliability, another benefit of using eye-tracking technology is that eye-movements are recorded almost continuously. It is common for researchers to use eye-tracking equipment that takes a measurement every 16.67ms and sampling frequency can be increased even further (Armstrong & Olatunji, 2012). Thus, unlike stimulus-response tasks, eye tracking is well-suited for distinguishing different components of attention on each trial (i.e., facilitated engagement, avoidance, disengagement difficulties).

To date, free-viewing tasks have been used in all of the published studies in which eye tracking has been employed to examine PTSD-related ABT (Armstrong, Bilsky, Zhao, & Olatunji, 2013; Bardeen & Daniel, 2017b; Beevers, Lee, Wells, Ellis, & Telch, 2011; Felmingham, Rennie, Manor, & Bryant, 2011; Kimble, Fleming, Bandy, Kim, & Zambetti, 2010; Lee & Lee, 2012). For free-viewing tasks, ABT is not measured based on task performance (e.g., speed of responding, identifying a predefined target). Instead, participants are instructed to view the stimuli that appear on the computer screen naturally, as if they were watching television. Much like the dot-probe and modified Stroop literature, there has been considerable differences in task design between eye-tracking studies. In terms of stimuli, photographs (Bardeen & Daniel, 2017b; Kimble et al., 2010; Lee & Lee, 2012), faces (Armstrong et al., 2013; Beevers et al., 2011), and words (Felmingham et al., 2011) have been used. Additionally, considerable variability in stimulus presentation duration has been observed (i.e., from 1,000 to 30,000ms; Felmingham et al., 2001; Beevers et al., 2011, respectively). Despite substantial between-study
variability in task design, one finding has been observed fairly consistently – Individuals with PTSD (or relatively higher posttraumatic symptoms in some cases) spend significantly more time looking at negatively-valenced stimuli than trauma control participants (i.e., attention maintenance; Armstrong et al., 2013; Bardeen & Daniel, 2017b; Kimble et al., 2010, Lee & Lee, 2012). The only study in which the results suggested facilitated engagement to both trauma-specific and threat-general stimuli was also the only study in which word stimuli were used and the measure of facilitation that was used is known for having unacceptably low reliability (i.e., number of initial fixations; Felmingham et al., 2011). One additional finding is of note. Beevers et al. (2011) asked U.S. soldiers to complete a free-viewing task, using face stimuli with facial expressions (i.e., happy, sad, fearful, neutral), prior to being deployed. Participants were assessed a second time for posttraumatic stress symptomatology after three months of being deployed to Iraq. Interestingly, soldiers who spent relatively less time attending to fearful faces at baseline (i.e., avoidance) were at greater risk for developing PTSD after being deployed compared to those who spent more time attending to fearful faces at baseline.

**Attentional Control as a Trauma-related Regulatory Mechanism**

The distress-buffering effects of attentional control have been reported in relation to a wide variety of maladaptive psychological outcomes and these protective effects also apply to those who are vulnerable to such outcomes (e.g., Armstrong, Zald, & Olatunji, 2011; Eisenberg, Fabes, Guthrie, & Reiser, 2000; Fergus et al., 2012; Jones et al., 2012; Richey et al., 2012). Nonetheless, relatively few published studies have examined attention control in the context of trauma and posttraumatic stress. Of those that have, the majority suggest that attentional control can be used as a trauma-related regulatory mechanism. For example, Bardeen and Read (2010) found that trauma-exposed adult participants with better attentional control recovered
significantly faster from trauma re-telling (i.e., verbalization of the first-person account of their most traumatic event) induced negative affect than individuals with relatively worse attentional control. In a cross-sectional study, Bardeen and Fergus (2016) found that attentional control moderated the relationship between three PTSD-related vulnerability factors (i.e., emotional distress intolerance, anxiety sensitivity, experiential avoidance) and posttraumatic stress symptoms, such that the relationship between these vulnerability factors and posttraumatic stress symptoms was significantly stronger among those with relatively worse attentional control. The authors concluded that attentional control may protect those with PTSD-related vulnerabilities from developing the disorder following trauma exposure. Preliminary longitudinal findings have similarly suggested the regulatory value of attentional control. Bardeen et al. (2015) found that those with relatively better attentional control, measured prior to a potentially traumatic event, reported relatively lower posttraumatic stress symptoms following that event in comparison to those that had relatively worse attentional control pre-trauma.

Bardeen and Orcutt (2011) considered the regulatory role of attentional control at a more proximal level (i.e., information processing) in an attempt to clarify mixed findings in the PTSD/ABT literature that may be a function of failing to account for the impact of top-down attentional processes on bottom-up reactivity. Specifically, they conducted a laboratory study in which participants completed a modified dot-probe task to assess ABT and a battery of self-report measures, which included a self-report measure of attentional control. They found that, among participants with relatively higher posttraumatic stress symptoms, those with better attentional control disengaged and shifted attention from threat to neutral stimuli, whereas those with relatively worse attentional control maintained attention on threat stimuli (pictorial stimuli that were rated high on arousal and negative valence [IAPS images]; Lang, Bradley, & Cuthbert,
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1999). This effect remained significant even after statistically controlling for state levels of anxious arousal. The authors hypothesized that the use of attentional control to disengage and shift attention from threat stimuli among those with higher posttraumatic stress symptoms may help to down-regulate emotional distress and sympathetic nervous system arousal in the short-term (Bardeen & Orcutt, 2011). Consistent with this proposition, shifting attention to safe or novel stimuli has been shown to reduce negative affect (Harman, Rothbart, & Posner, 1997; Nolen-Hoeksema & Morrow, 1993) and mild distraction has been shown to help expedite fear reduction during exposure therapy (Johnstone & Page, 2004). The authors also acknowledged that consistently shifting attention away from threat stimuli may be perceived as maladaptive avoidance, but offered the possibility that using attentional control in this manner may reduce the likelihood that one uses even less adaptive regulatory strategies that are known to maintain and exacerbate posttraumatic stress (e.g., substance use, physical escape). By reducing the intensity of the emotional experience, the individual may be able to remain in the environment in which the fear-provoking stimuli is present, thus increasing the likelihood that inhibitory learning will occur and symptoms will be reduced.

Before considering longitudinal research, which is necessary to determine the adaptive value of using attentional control to regulate the emotional distress that is associated with viewing threat stimuli among those with higher posttraumatic stress, one other significant limitation in this line of research should be addressed. Attentional control is often assessed via self-report (Derryberry & Reed, 2002). As described above, evidence suggests that attentional control processes can be enacted in a fraction of a second (e.g., Shomstein et al., 2012), and thus, it may be difficult to accurately report on cognitive processes that occur so rapidly that they go unnoticed on a moment-by-moment basis. In fact, some have suggested that self-report measures
of attentional control may be a better indicator of beliefs about attentional control rather than providing an index of attentional control abilities (Spada, Georgiou, & Wells, 2010). Moreover, self-reported attentional control has failed to correlate with behavioral measures of attentional control processes (e.g., working memory, inhibitory ability) in some studies (Quigley, Wright, Dobson, & Sears, 2017).

To address the limitation of using self-report to assess attentional control, while also replicating the moderation effect observed by Bardeen and Orcutt (2011), Bardeen et al. (2016) incorporated a behavioral measure of attentional control and a dot-probe task into their laboratory study. Additionally, ABT scores were calculated using the trial-level bias method to improve score reliability and account for the temporal dynamics of ABT (Zvielli et al., 2015). As predicted, attentional control (measured via a behavioral task) moderated the association between PTSD status and ABT, such that among those with PTSD, those with relatively worse attentional control exhibited significantly greater ABT (Bardeen et al., 2016). This effect remained significant even after statistically controlling for variability on trials with only neutral content, thus increasing confidence that the observed effect was specific to threat and not a function of general variability in responding.

Preliminary longitudinal findings suggest that pre-trauma attentional control may serve as a protective factor against developing PTSD in the acute aftermath of a trauma (Bardeen et al., 2015). Evidence also suggests that those with PTSD and relatively better attentional control disengage and shift attention from threat to neutral stimuli, while those with PTSD and relatively worse attentional control maintain attention on threat stimuli (Bardeen & Orcutt, 2011, Bardeen et al., 2016). Bardeen and Daniel (2017b) conducted a longitudinal study to determine whether deploying attention away from threat is adaptive over a prolonged period (i.e., six months). As
described by Bardeen and Daniel (2017b), two hypotheses were plausible. First, temporarily disengaging attention from threat stimuli and refocusing elsewhere may serve to down-regulate sympathetic nervous system arousal and associated emotional distress. By reducing the intensity of the emotional experience, the individual may be able to remain in the environment in which the fear-provoking stimuli is present, rather than using more extreme avoidance strategies, such as physical escape, which do not provide opportunities for new learning and allow for fear extinction. Although the intensity of the uncomfortable emotion is reduced, it is still experienced.

Second, the chronic inflexible use of attentional control processes to avoid threat information may reduce emotional arousal in the short-term, but maintain, and perhaps exacerbate posttraumatic stress symptoms over time by failing to provide the opportunity for new learning.

To test these hypotheses, trauma-exposed adults participated in a laboratory session in which they completed self-report measures (e.g., attentional control), behavioral tasks that separately assessed the primary components of attentional control, and a free-viewing task in which eye movements were recorded in response to threat and neutral stimuli over the course of 60 trials (Bardeen & Daniel, 2017b). Eye-tracking technology was used to ensure reliability of ABT scores and to provide a more direct, overt measure of attention allocation. The stimulus set that was presented during the free-viewing task (i.e., threat-neutral pairings) had been used in previous research (Bardeen, 2015) and the format of presentation was similar to Bardeen and Orcutt (2011) and Bardeen et al. (2016). Specifically, for each trial, two images (threat-neutral pairings) appeared side-by-side on the screen for 3,000ms and participants were free to pay as much, or as little attention to each image as they desired; a response was not required. To examine within-trial variability in ABT, dwell time (i.e., proportion of time attending to threat versus neutral) was calculated in 500ms epochs (i.e., 0-500, 501-1,000, 1,001-1,500, 1,501-
Additionally, pupil response was assessed and served as an indicator of emotional arousal in response to task stimuli (Bradley, Miccoli, Escrig, & Lang, 2008). Based on the hypothesis that shifting attention from threat to neutral stimuli down-regulates sympathetic nervous system arousal, Bardeen and Daniel (2017b) hypothesized that, among participants with relatively higher posttraumatic stress symptoms, those with better attentional control would exhibit attenuated pupillary response during the free-viewing task compared to those with worse attentional control. Finally, participants completed a battery of self-report measures online, including a measure of posttraumatic stress symptoms, six months after completing the laboratory session.

Consistent with previous research (Bardeen & Orcutt, 2011), self-reported attentional control moderated the relationship between posttraumatic stress symptoms and ABT, such that among those with relatively higher posttraumatic stress symptoms, those with better attentional control disengaged from threat and shifted attention to the neutral stimulus, while those with worse attentional control maintained attention on threat. Importantly, this finding was replicated using behavioral measures of attentional control. Specifically, inhibitory ability appeared to be driving the moderation effect. This effect was most pronounced at a relatively later stage of information processing (1,500 to 3,000ms), but not at a stage of processing indicative of facilitated engagement (i.e., 0-500ms). This might help explain the apparent discrepancy between the vigilance-avoidance and attention maintenance hypotheses. While a difference in initial reflexive orienting toward threat stimuli based on posttraumatic stress symptomatology was not observed in this study, findings suggest that among those with higher posttraumatic stress symptoms, those with relatively worse inhibitory ability lack the requisite resources to disengage attention from threat stimuli and refocus elsewhere, thus resulting in attention
maintenance. In contrast, those with higher posttraumatic stress symptoms and relatively better inhibitory ability quickly disengaged attention from threat and maintained attentional focus on neutral stimuli once disengagement had occurred (i.e., threat avoidance). Additionally, results of this study suggest that this pattern of avoidance, among those with higher posttraumatic stress symptoms and relatively better attentional control, leads to short-term relief from emotional distress (i.e., down-regulation of sympathetic nervous system arousal), as this group exhibited significantly lower pupillary reactivity to threat stimuli in comparison to those with higher posttraumatic stress symptoms and relatively worse attentional control.

Results from the longitudinal portion of the study suggest that using attentional control to shift attention away from threat stimuli and down-regulate emotional arousal maintains, and perhaps exacerbates, posttraumatic stress symptoms over a six-month period. It is important to keep in mind that the maladaptive nature of this effect is specific to participants who had relatively higher posttraumatic stress symptoms to begin with. However, Beevers et al. (2011) found that soldiers who exhibited the same pattern of threat avoidance, albeit to fearful faces, were at greater risk for developing PTSD after being deployed compared to those who attended to fearful faces more often at the initial assessment. To understand the effect observed by Bardeen and Daniel (2017b), it may important to distinguish ability (i.e., abilities underlying attention control: inhibition, shifting, working memory updating) from the effortful application of ability (i.e., attentional deployment). As described, information processing theories of emotion regulation suggest that the flexible use of attentional control is important for maintaining psychological well-being (Gross, 2015). The pattern of threat-related avoidance exhibited in this study by those with higher posttraumatic symptoms and relatively better attentional control suggests a rigid fear-based approach to reducing emotional arousal. In contrast, flexible use of
attentional control suggests a willingness to experience fluctuations in emotions and affective states. As identified in the *DSM-5* (APA, 2013), the use of avoidance to provide short-term relief from aversive internal experiences (i.e., trauma-related bodily sensations, emotions, memories, thoughts) is a symptom of PTSD. As suggested by the results of Bardeen and Daniel’s (2017b) study, avoidance of aversive internal experiences (i.e., experiential avoidance) that are associated with a traumatic event, and threat stimuli in general (i.e., fear generalization), may reduce trauma-related distress in the short-term, thus reinforcing the likelihood that attentional avoidance of threat stimuli will continue. As this regulatory approach is used more often (i.e., “pre-tuning”), it should become easier to enact, eventually becoming an almost automatic reflex to specific stimulus categories (i.e., “prepared-reflex;” Verbruggen, 2017). Over time, the chronic use of attentional avoidance prevents disconfirmation of faulty threat appraisals, thus resulting in the continued use of maladaptive avoidance behaviors and the maintenance of posttraumatic stress.

The findings of Bardeen and Daniel (2017b) highlight a broader issue regarding the linear assumption that is often made regarding the nature of constructs that represent top-down regulation. That is, it is typically assumed that the more you have (e.g., attentional control, inhibitory control, self-regulation/control), the better off you are (Tangney, Baumeister, & Boone, 2004). In a chapter on “Self-regulation: Self-control,” Peterson and Seligman (2004) write, “We have focused on the positive aspects of self-regulation and self-control and have not discussed the possible drawbacks of self-control. This omission arises from our belief that there is no true disadvantage of having too much self-control” (p. 515). The results from Bardeen and Daniel (2017b) suggest that attentional control, like any other tool of self-regulation, can be used in such a way as to result in maladaptive outcomes. Consistent with this proposition,
examinations of the role of maladaptive overcontrol, which requires a high level of top-down inhibitory ability, in the development of psychopathology (e.g., anorexia nervosa) are increasing. Additionally, interventions have recently been developed that aim to relax inhibitory control and increase flexibility among individuals suffering from overcontrol-related pathology (e.g., Lynch, 2018).

The problem of maladaptive overcontrol has also received some attention in the emotion regulation literature. As described by Gross (2015), some individuals are prone to “delayed stopping” in the process of emotion regulation. That is, they continue to employ an emotion regulation strategy well beyond the point at which regulation is needed, thus resulting in overtaxed cognitive resources and a wide variety of maladaptive outcomes (e.g., inhibiting emotional expression across contexts, which is sometimes adaptive [business meeting], and other times maladaptive [in the presence of family]). While it is important to consider individual differences in top-down attentional control abilities to understand the role of attention in the development and maintenance of trauma-related distress, more emphasis should be placed on how and when these abilities are used. Specifically, it seems important to assess whether individuals employ top-down attention with chronic rigidity across contexts or flexibly based on the demands of a given situation. Some evidence suggests that the ability to flexibly shift between attentional avoidance and engagement based on threat intensity is psychologically healthy (i.e., avoiding in high threat situations and engaging in low-moderate threat situations; Sheppes, Scheibe, Suri, & Gross, 2011).

Also of note, Bardeen and Daniel (2017b) found that the combination of high pupillary reactivity and high attentional control buffered the effect of posttraumatic stress symptoms at baseline on posttraumatic stress symptoms six months later. This finding suggests that the
combination of ability (i.e., attentional control) and willingness to experience short-term emotional distress may be protective. This finding is consistent with a functional-contextual perspective in which the chronic and rigid avoidance of unwanted internal experiences reduces short-term emotional distress, but paradoxically exacerbates emotional distress over prolonged periods of time (Hayes, Luoma, Bond, Masuda, & Lillis, 2006). This finding is also consistent with empirical evidence that those with outcome-specific vulnerabilities and greater willingness to experience uncomfortable emotions report greater short-term emotional distress in response to negative mood induction, but relatively less long-term maladaptive outcomes (Bardeen, 2015). In contrast, those with outcome-specific vulnerabilities and greater avoidance of uncomfortable emotions report less short-term distress in response to negative mood induction, but greater maladaptive long-term outcomes.

**Attention Bias Modification**

A great deal of effort has been spent researching emotion regulation strategies that are employed at later stages of the emotion generative process (Gross & Thompson, 2007), and this research has been used to support the use of resource-intensive interventions that focus on altering emotions after they are more fully developed (e.g., cognitive therapy/ restructuring). However, it may be easier and less resource-intensive to target regulatory processes that occur earlier in the emotion generative process before an emotion has completely unfolded (e.g., attentional deployment, situation modification). Attention bias modification (ABM), a computer delivered treatment for anxiety- and fear-related pathology, was developed to train attention (implicitly) away from threat and toward non-threat stimuli (i.e., threat avoidance). ABM training is conducted most often using a modified version of the dot-probe task. Specifically, in
ABM, the probe appears in the spatial position previously held by the neutral stimuli on the majority of task trials (e.g., 80%-100% of the time: Schoorl, Putman, & Van Der Does, 2013).

Relatively few randomized control trials (RCTs) have been conducted in which ABM has been used to treat individuals with PTSD (Badura-Brack et al., 2015; Schoorl et al., 2013; Kuckertz et al., 2014). In these studies, and in the application of ABM in the broader fear/anxiety literature, the control condition typically consists of completion of the standard dot-probe task; the probe appears equally in place of both types of stimuli (i.e., neutral and threat). Using this approach, Schoorl et al., (2013) found that both conditions (ABM and the standard dot-probe) were equally effective in reducing posttraumatic stress symptoms among outpatient participants with chronic PTSD. However, neither intervention performed better than use of a placebo pill and neither intervention altered ABT. Schoorl et al., (2013) concluded that ABM is not an effective treatment for PTSD.

In another RCT, Kuckertz et al. (2014) assigned patients with PTSD who were receiving front line treatments for the disorder (i.e., prolonged exposure or cognitive processing therapy), as well as pharmacological intervention, to receive ABM or the standard dot-probe task as an adjunct. Although PTSD symptoms decreased in both conditions, the decrease was significantly larger for participants in the ABM condition compared to control. Interestingly, symptom reductions were largest among participants who exhibited avoidance of threat, rather than ABT, at baseline. This finding runs counter to the fundamental assumption of ABM, that ABT plays a causal role in the development of PTSD, and thus, can be reduced through the use of ABM in order to reduce PTSD symptoms. To explain this finding, Kuckertz et al. (2014) hypothesized that “it may be the case that individuals who initially present with a bias away from threat possess a cognitive strength that is more easily maximized through attention training away from
threat, relative to individuals who have a pre-existing difficulty attending away from threat” (p. 33). Evidence suggests that, among individuals with PTSD, those with relatively better attentional control exhibit threat avoidance rather than ABT (Bardeen & Orcutt, 2011, Bardeen et al., 2016, Bardeen & Daniel, 2017b). Following from this evidence, Kuckertz et al. (2014) may have been correct that patients in their study who exhibited attentional avoidance at baseline had a relative strength in cognitive ability (e.g., attentional control). However, it seems unlikely that ABM would somehow draw on this ability to alleviate PTSD symptoms. Specifically, it is not clear why individuals with PTSD who already exhibit threat avoidance would benefit from an intervention designed to enhance threat avoidance, especially given evidence that using attentional control to avoid threat maintains PTSD symptoms (Bardeen & Daniel, 2017b). It may be that the relative difference in cognitive ability at baseline interacted with one of the many components of the primary treatment that the patients were receiving (e.g., exposure, cognitive processing, pharmacological intervention) to enhance symptom reduction, but this hypothesis would need to be explored in future research.

Finally, perhaps one of the most unusual findings if one assumes that ABM works by training attention away from threat, comes from a set of RCTs in which participants (Veterans of Israel’s Defense Force and the U.S. Military) were randomly assigned to receive ABM or the standard dot-probe task (Badura-Brack, 2015). In contrast to Kuckertz et al. (2014), participants assigned to the control condition exhibited significantly greater reductions in PTSD symptoms compared to those assigned to the ABM condition. Additionally, those who completed the standard dot-probe (typically used as a control condition) exhibited significant reductions in attention bias variability, whereas as those in the active ABM condition did not (Badura-Brack, 2015). Badura-Brack et al. (2015) explained these findings by suggesting that the standard dot-
probe task, with the probe appearing equally in place of both types of stimuli, helps train
attention toward task success rather than away from threat stimuli, thus promoting flexibility of
attentional control rather than threat avoidance.

Many more ABM studies have been conducted with people suffering from other forms of
fear/anxiety-related pathology. Unfortunately, the results of these studies do not provide clarity
surrounding issue of ABM efficacy. Although some meta-analytic evidence suggests small- to
medium-sized effects for the use of ABM for treating anxiety and related disorders (e.g.,
Hakamata et al., 2010), Cristea, Kok, and Cuijpers (2015) found that previously-significant
effects became nonsignificant when (a) adjusting for publication bias, (b) accounting for extreme
outliers, and (c) confining analyses to patient samples. These equivocal findings are less
perplexing when one considers that the basic assumption of ABM, that individuals with fear- and
anxiety-related pathology (i.e., PTSD) preferentially process threat, appears to be incorrect.
Results from a number of studies (Bardeen & Daniel, 2017b, Bardeen & Orcutt, 2011; Bardeen
et al., 2016; Derryberry & Reed, 2002; Ho, Yueng, & Mak, 2017) suggest that assessment of top-
down attentional control processes is important when designing studies that seek to understand
threat processing in PTSD and related disorders.

Although standard ABM may not be suitable for individuals with PTSD and relatively
better attentional control, this approach may have value for reducing PTSD symptoms among
those that lack the ability to maintain threat disengagement (i.e., PTSD and lower attentional
control). In contrast, those that exhibit chronic and inflexible threat avoidance (i.e., PTSD and
higher attentional control), may be better served by participating in interventions that promote
flexibility of attentional control (e.g., the attention training component of Emotion Regulation
Therapy: Renna et al., 2018; the Attention Training Technique: Wells, 1990; see Fergus &
Bardeen, 2016, for a review). Additionally, treatments that have been shown to be effective in increasing willingness to stay in contact with uncomfortable emotions and related internal experiences may be beneficial for individuals who exhibit rigid threat-avoidance (e.g., Acceptance and Commitment Therapy: Hayes et al., 2006; Mindfulness-Based Stress Reduction: Kabat-Zinn, 1990).
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