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An Investigation of Emotional Numbing in Veterans with Posttraumatic Stress Disorder Symptoms

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Doctor of Philosophy

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Abstract

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Despite significant advances in empirically supported treatments for posttraumatic stress disorder (PTSD), many PTSD sufferers do not fully remit. Research has increasingly focused on examining the role deficits in emotional functioning may play among those who develop chronic PTSD. Residual emotional numbing and associated functional impairment are commonly reported, yet emotional numbing remains poorly defined and poorly understood. Most studies have relied on ratings of three DSM-IV Cluster C numbing symptoms as the only measure, and very few published studies have reported on psychophysiological correlates of self-reported emotional numbing. The present study investigated correlates of emotional numbing within a sample of male veterans with trauma histories (n = 47) using a recently developed, more comprehensive measure of emotional numbing. Consistent with predictions, self-reported emotional numbing was associated with higher self-reports of attachment insecurity, relationship distress, and lower compassion for self and others. Contrary to predictions, emotional numbing was positively associated with heart rate variability and negatively associated with heart rate during resting baseline and presentation of emotional stimuli, indicating diminished physiological responding. Psychophysiological arousal and self-reported arousal were not associated with one another, and physiological arousal did not differ across conditions that involved presentation of positive and negative images. These results did not provide support for the prevailing notion that psychophysiological hyperreactivity characterizes PTSD samples. A secondary aim of the study was to investigate the credibility and acceptability of a compassion meditation intervention targeting emotional numbing symptoms in a subgroup of participants who reported a history of diagnosed PTSD and interest in receiving treatment for emotional numbing symptoms (n = 10). In this small pilot, veterans who completed Cognitively Based Compassion Training (CBCT) did not report increased subjective feelings of compassion for self and others, as had been hypothesized, but did report significantly decreased numbing and PTSD symptoms. Moreover, CBCT was rated as highly acceptable and useful, and drop out was low. Thus, further evaluation of the potential for compassion meditation to address emotional numbing is warranted.

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Table of Contents

Dissertation Overview 7

Background Literature Review 9

Emotional Numbing in PTSD 10

Correlates and Consequences of Emotional Numbing 12

Compassion Training as a Novel Intervention for Residual PTSD Symptoms 22

Research Aims and Hypotheses 26

Method 28

Participants and Procedures 28

Measures 30

Baseline self-report measures 30

Psychophysiological measures and laboratory tasks 35

Credibility, motivation, acceptability, and engagement with CBCT 38

Intervention 40

Statistical Analyses 40

Results 42

Preliminary Analyses 42

Participant Enrollment and Flow 44

Hypothesis 1a: Associations Between Emotional Numbing Measures 45

Hypothesis 2a: Associations Between Emotional Numbing and Cardiac Variables 46

Hypothesis 2b: Associations Between Emotional Numbing and Self-Reported Arousal 50

Hypothesis 2c: Associations Between Emotional Numbing and Relational Functioning 50

Hypothesis 2d: Associations Between Emotional Numbing and Compassion 51

Hypothesis 3a: CBCT Engagement and Satisfaction 51

Hypothesis 4a: Exploring Pre-Post Change Following CBCT 52

Discussion 54

Strengths and Limitations 65

Future Directions 68

Conclusions 70

References 72

Appendix A: Tables 90

Appendix B: Figures 98

An Investigation of Emotional Numbing in Veterans with Posttraumatic Stress Disorder Symptoms

Dissertation Overview

The purpose of this study was to better understand emotional numbing in a sample of male veterans who reported a range of emotional numbing and other PTSD symptoms, and to pilot a novel intervention to target these symptoms. Despite the significant improvements demonstrated in empirically supported treatments for posttraumatic stress disorder (PTSD; Foa, Keane, Friedman, & Cohen, 2009), many PTSD sufferers do not fully remit, continuing to struggle with residual symptoms and associated functional impairment (Zlotnick et al., 2004). Research in the field of PTSD has increasingly focused on the role of emotional functioning in the maintenance of the disorder over time. Specifically, emotional numbing symptoms and related interpersonal difficulties, including attachment insecurity (Franz et al., 2014; Ruscio, Weathers, King, & King, 2002), have been identified as major risk factors for the development of chronic PTSD (Breslau & Davis, 1992; Troop & Hiskey, 2013).

Most studies examining emotional numbing in PTSD have operationally defined the phenomenon based only on endorsements of three diagnostic symptoms from the avoidance cluster (Cluster C) of the DSM-IV criteria: those thought to indicate numbing (i.e., feeling distant from others, having decreased interest in activities, and feeling numb/constricted affect) (Feeny, Zoellner, Fitzgibbons, & Foa, 2000; Flack, Litz, Hsieh, Kaloupek, & Keane, 2000; Roemer, Orsillo, Borkovec, & Litz, 1998; Ruscio et al., 2002). However, recent advancements in our understanding of emotional deficits in PTSD have revealed major limitations to this method of measurement (Orsillo, Theodore-Oklota, Luterek, & Plumb, 2007). For instance, this conceptualization of emotional numbing is conflated with anhedonia and social withdrawal, and does not take into account the possibility that reports of numbing might differ across different types of emotional experiences (e.g., positive vs. negative emotions). Furthermore, rather than supporting a nonspecific "numbing" of emotional responses, some theorize that emotional functioning in PTSD may be characterized by hyper-responsivity to negative emotional stimuli and hypo-responsivity to positive emotional stimuli (Litz & Gray, 2002). The number of studies investigating the construct of emotional numbing is quite limited, and moreover, no studies with adult populations have assessed emotional numbing beyond using the Cluster C symptom ratings just described.

Finally, few studies have examined the psychophysiological correlates of self-reported emotional numbing. In order to better understand the phenomenon of emotional numbing in chronic PTSD, studies employing more thorough and multi-modal evaluations (e.g., carefully assessing the emotional, psychophysiological, and relational experiences of chronic sufferers) are needed. Thus, the primary goal of this study was to shed light on the relationships between self-reported emotional numbing, psychophysiological responses and self-reported arousal in response to emotional stimuli, and interpersonal functioning. We also included a more comprehensive measure of emotional numbing in addition to the standard Cluster C numbing symptom ratings.

The second major goal of this study was to pilot a novel intervention that in theory should target the construct of emotional numbing very directly, and evaluate the acceptability and feasibility of that intervention in veterans seeking help for emotional numbing. Cognitively-Based Compassion Training (CBCT; Ozawa-de Silva, Dodson-Lavelle, Raison, & Negi, 2012) is a secular compassion training program that has shown promise in reducing physiological indices of stress and has been shown to be acceptable to a wide range of adult populations. At the present time there are no evidence-based interventions specifically designed to address the residual symptoms of emotional numbing and associated experiences of social disconnection after patients have completed first line PTSD treatment (e.g., Prolonged Exposure or Cognitive Processing Therapy). Although CBCT provided as a protocol intervention has not been adequately established as an empirically-supported "clinical" intervention for any specific disorders, the rationale for piloting it with this sample of partial responders is compelling. CBCT is unique in that the training not only includes foundational mindfulness practices to increase awareness of internal emotional and physiological experiences, but also includes the teaching of analytical meditations designed explicitly to cultivate compassionate values, increase positive feelings of connectedness to others, and minimize feelings of isolation. Furthermore, initial empirical evidence has demonstrated improvements on variables that would be expected to be relevant to emotional numbing (e.g., increased empathic accuracy; Desbordes et al., 2012; Mascaro, Rilling, Negi, & Raison, 2013; Pace et al., 2009; Pace et al., 2013). Thus, CBCT is theoretically well suited to address the experiences of emotional numbing and social disconnection that characterize chronic PTSD.

Background Literature Review

In this section, we review the theoretical and empirical research suggesting that emotional numbing is an important and understudied phenomenon in the context of chronic PTSD. Next, we review data describing what is currently known about the relationships between self-reported emotional numbing and measures of emotional, psychophysiological, and social/relational functioning. Based on this literature review, several research aims and hypotheses were proposed and tested using data collected from a diverse sample of male veterans with trauma histories and a range of PTSD symptoms.

Emotional Numbing in PTSD

Unlike the hallmark hyper-arousal and re-experiencing symptoms of PTSD, the role and character of emotional numbing in individuals who suffer from chronic posttraumatic symptoms is not well understood (Litz & Gray, 2002). In the DSM-IV-TR (American Psychiatric Association, 2000), emotional numbing falls under the "avoidance" cluster (i.e., Cluster C), but factor-analyses have consistently revealed that emotional numbing symptoms are distinct from avoidance symptoms (e.g., Bensimon et al., 2013; Foa, Riggs, & Gershuny, 1995). Recent adjustments to the DSM-5 PTSD symptom criteria separated emotional numbing from avoidance symptoms, but emotional numbing is now subsumed within a fourth cluster representing negative alterations in cognitions and mood associated with the traumatic event. This new cluster includes anhedonia and social withdrawal as well as two specific difficulties with emotional responses: 1) the constricted experience of positive emotions and 2) the persistence of negative emotions (e.g., fear, horror, anger, guilt, shame) associated with the trauma. However, the extent to which emotional numbing is restricted to positive emotions is not yet clear, with some evidence supporting the notion that numbing associated with PTSD is specific to positive emotions (e.g., Kashdan, Elhai, & Frueh, 2007), and other evidence suggesting an equally important role of numbing to negative emotions, like sadness, fear, and anger (e.g., Allwood, Bell, & Horan, 2011; Kerig, Bennett, Chaplo, Modrowski, & McGee, 2016). Given the uncertainty about exactly what emotional numbing is, along with the fact that the majority of research linking emotional numbing to persistent PTSD symptoms has focused on general numbing of emotions or combined avoidance/numbing symptoms, further research is needed to more precisely understand this construct.

A substantial body of research has demonstrated the major role played by emotional numbing in both the development and maintenance of posttraumatic symptomatology. In a prospective study of motor vehicle accident survivors, endorsement of emotional numbing assessed one month after the traumatic event was the strongest predictor of developing PTSD five months later (Harvey & Bryant, 1998). The severity level of emotional numbing symptoms reported by trauma survivors two weeks after a trauma exposure predicted PTSD severity three months later (Feeny et al., 2000). Likewise, the extent to which an individual experienced emotional numbing during a traumatic event was associated with the later development of posttraumatic symptomology (Roemer et al., 1998). It has been hypothesized that while re-experiencing and hyperarousal symptoms may have a greater impact on psychological functioning immediately after a traumatic event, emotional numbing (sometimes called "dysphoria") symptoms may have greater impact and salience long after the trauma has occurred (Pietrzak, Goldstein, Malley, Rivers, & Southwick, 2010). These numbing symptoms have been implicated to be among the dominant enduring symptoms in cases of chronic PTSD, both in adults (McFarlane, 2000) and in samples of young adults exposed to trauma (Breslau & Davis, 1992).

Nevertheless, our ability to further understand and alleviate the distress associated with emotional numbing is currently limited by how the field has operationally defined and measured the construct, in addition to the relatively small number of rigorous empirical studies on the topic. There are many questions yet to be answered. For example, do individuals who report emotional numbing experience constriction in all emotions, or do they respond differently to positive versus negative emotions? Is emotional numbing constant, phasic, or activated by certain internal (e.g., thoughts, memories) or external (e.g., interpersonal conflict) stimuli? What roles do external (e.g., social functioning) and internal (e.g., psychophysiological) processes play in emotional numbing? A more thorough examination of questions like these is sorely needed to begin to understand how emotional numbing becomes chronic and to design effective interventions.

Combat veterans make up one population that suffers from high rates of PTSD, with a lifetime conditional probability ranging from 12% to 35%, depending on combat severity (Wisco et al., 2014); therefore, this is an important group in which to study the phenomenon of emotional numbing. Thus, the current study sought to explore some of the questions above in a sample of male veterans with a range of traumatic experiences, 87% of whom reported combat exposure. Among men, PTSD is more likely to become chronic when there is combat trauma than with other types of trauma (Prigerson, Maciejewski, & Rosenheck, 2001). Furthermore, men who have experienced combat trauma compared to other types of trauma are more likely to have unresolved PTSD symptoms, such as emotional numbing (Prigerson et al., 2001). A recent study examining the factor structure of the new DSM-5 PTSD criteria in a sample of nearly 1,500 veterans found that of all the symptom clusters, the emotional numbing cluster had the strongest associations with both depression and poorer mental-health functioning more broadly (Tsai et al., 2015). Thus, improving our understanding of what emotional numbing is and how it relates to other domains of functioning will be critical for informing PTSD intervention efforts, particularly for chronic sufferers.

Correlates and Consequences of Emotional Numbing

One way to better understand emotional numbing is through research examining the nature, correlates, and consequences of emotional numbing, which has historically been limited. However, research and interest in this phenomenon has gradually increased (e.g., Felmingham et al., 2014; Orsillo et al., 2007; Tull & Roemer, 2003). The section that follows will describe the emotional, psychophysiological (with a focus on cardiac function), and social/relational processes associated with emotional numbing and posttraumatic symptoms more broadly.

Emotional numbing and emotional functioning. Even in its chronic form, PTSD is thought to be cyclical or phasic, characterized by states of diminished emotional responding (i.e., emotional numbing) and states of heightened emotional reactivity, which are thought to be related to re-experiencing and hyperarousal to trauma-reminders (Foa, Zinbarg, & Rothbaum, 1992; Litz, Orsillo, Kaloupek, & Weathers, 2000). Prior studies attempting to clarify the nature of emotional processing in PTSD have used a number of methodologies, often in conjunction, in an effort to understand this phenomenon. These methods have included self-reported ratings of discrete emotions, emotional valence (rated on a linear dimension from positive to negative), emotional arousal/intensity (rated on a linear dimension from low arousal to high arousal), psychophysiological measures, and fear/threat-related neural activation patterns.

Some research suggests that the construct of emotional "numbing" disguises the complex and context-dependent nature of emotional functioning in individuals with trauma histories (Litz, 1992; Litz & Gray, 2002; Orsillo et al., 2007). Litz and colleagues (1992; 2002) have argued that individuals with PTSD are fully capable of experiencing and expressing the full range of feeling states that were available to them before the trauma. These authors proposed that emotional dysfunction following PTSD is characterized by first, an "acquired predisposition" to respond negatively to negatively-valenced (or trauma-associated but neutral) stimuli with a higher degree of emotional intensity and a lower threshold of stimulus intensity (Litz & Gray, 2002), and second, a higher degree of stimulus intensity is required to access the full range of appetitive (positive or pleasant) emotional states. Thus, it may not be the case that the emotional processing capacities in PTSD are diminished or dampened globally, as the term emotional numbing would imply, but instead that the information-processing and psychophysiological systems are highly sensitized to perceive potential threats, resulting in a lowered threshold of intensity needed for negative stimuli to trigger negative emotions and a higher threshold of intensity needed for positive stimuli to elicit positive emotions.

Empirical evidence suggests that the capacity to express and experience positive feelings is constrained when patients with PTSD are exposed to reminders of their trauma (Amdur, Larsen, & Liberzon, 2000; Litz et al., 2000). Other evidence suggests a dampening of response to positive stimuli, regardless of context (e.g., Spahic-Mihajlovic, Crayton, & Neafsey, 2005). In a small sample of civilians with PTSD resulting from physical assault or motor vehicle accidents ($n = 23$), Felmingham et al. (2014) found that PTSD participants rated happy facial expressions as less intense than did trauma-exposed controls. Likewise, Frewen et al. (2012) found that for women with PTSD, emotional numbing symptoms were associated with lower positive affect in response to positively valenced scripts. Consistent with theories put forward by Litz and others (e.g., Litz, 1992), some studies have also demonstrated heightened reports of discrete negative emotions in PTSD (Amdur et al., 2000; Orsillo, Batten, Plumb, Luterek, & Roessner, 2004).

Yet, findings have been inconsistent, yielding an unclear pattern of results both across indices of arousal and between studies. For instance, although Litz et al. (2000) found diminished zygomatic (i.e., smile) facial muscle reactivity to positive images for PTSD veterans exposed to a combat-prime, they found no differences in self-reported arousal ratings, corrugator muscle activity, or skin conductance responses to positive images between veterans with and without PTSD, or between combat-prime and neutral-prime conditions. Furthermore, there was no evidence for heightened arousal to negative stimuli in the PTSD group, whether or not they were primed with trauma-related stimuli. In contrast, despite finding differences in self-reported arousal to positive and negative images in combat veterans with PTSD compared to controls, Amdur et al. (2000) found that psychophysiological arousal was not associated with self-reported arousal. Other evidence using neural correlates suggests that emotional reactivity may be diminished across different types of emotions. For instance, women with PTSD showed lower activation than controls within the dorsomedical prefrontal cortex to *both* negatively and positively valenced scripts (Frewen et al., 2012). It may be that emotional “numbing” is more reliably observable using measures of overt or involuntary behavior, such as psychophysiological responses to stimuli as individuals who suffer from emotional numbing often have difficulty identifying and expressing their emotional experiences (Litz & Gray, 2002). However, some studies suggest that self-reported distress may be a good index of physiological distress, particularly when individuals with PTSD are exposed to trauma-related content (Marx et al., 2012). In summary, it remains unclear across the literature whether self-reported arousal corresponds with psychophysiological arousal, and the extent to which emotional numbing is related to these indices.

Emotional numbing and psychophysiological functioning. Examining psychophysiological functioning is essential to improving our understanding of emotional numbing not only because of the theoretical and empirical foundations described below, but also due to the limitations of subjective measures. First, patients may not be able to accurately self-monitor their own emotional experiences, especially since numbing likely includes an element of emotional suppression (Litz et al., 1997; Tull & Roemer, 2003) and questionnaires require patients to reflect on global experiences (e.g., “feeling numb”) over long periods of time (e.g., “since the event…”) that are typically paraphrased directly from DSM diagnostic criteria. Furthermore, there is evidence that Vietnam combat veterans with chronic PTSD admit to strategically choosing to withhold their internal emotional reactions, as compared to well-adjusted veterans (Roemer, Litz, Orsillo, & Wagner, 2001), calling into question the accuracy of reports of constrained emotions. At the same time, a chronic pattern of intentionally concealing one's inner feelings could plausibly lead to a genuine sense of emotional numbing (through suppression and experiential avoidance).

Psychophysiological dysregulation with associated symptoms (e.g., intense physical reactions to reminders of the traumatic event, such as heart pounding and rapid breathing; feeling jumpy and easily startled) is a major diagnostic feature of PTSD more broadly. For instance, a number of studies have demonstrated that self-reported heightened psychophysiological activity (i.e., hyperarousal) predicts PTSD onset and symptom severity (e.g., Breslau & Kessler, 2001; Elsesser, Sartory, & Tackenberg, 2005). Litz (1992) has argued that emotional numbing may occur as a result of efforts to manage re-experiencing and hyperarousal symptoms. Consistent with this argument, studies with Vietnam combat veterans have demonstrated that self-reported hyperarousal symptoms account for more variance in emotional numbing symptoms than any other symptoms of PTSD, with strong effect sizes (Flack et al., 2000; Litz et al., 1997).

However, there have been very few studies to date examining the psychophysiological correlates of emotional numbing, specifically. Only two peer-reviewed studies (Flack et al., 2000; Schoenberg, Sierra, & David, 2012) and three unpublished dissertations (Heuton, 2000; Jaeger, 2011; Robinson, 2011) have investigated relationships between psychophysiological measures and emotional numbing symptoms. In a large sample of male combat veterans, Flack and colleagues (2000) reported a small but significant direct association between heart rate reactivity to trauma-cues and an emotional numbing composite score, such that greater emotional numbing was associated with greater heart rate reactivity to a trauma-specific stimulus.

However, when accounting for other variables, psychophysiological measures failed to predict emotional numbing scores in multiple regression models. Schoenberg et al. (2012) found evidence of abnormal autonomic regulation in patients with depersonalization disorder and emotional numbing symptoms, with patients showing higher resting skin conductance levels and greater nonspecific skin conductance responses as compared to healthy controls. At this point, there is a great deal left to learn about whether and how psychophysiological functioning is altered in individuals reporting emotional numbing.

Despite the lack of studies reporting on relationships between emotional numbing and psychophysiology, far more research has examined the psychophysiology of PTSD, which may provide a basis for predicting how emotional numbing and psychophysiological functioning are related. PTSD is associated with autonomic nervous system (ANS) dysfunction, likely characterized both by an overactive sympathetic nervous system (SNS) and a hypoactive parasympathetic nervous system (PNS) (Buckley & Kaloupek, 2001; Hauschildt, Peters, Moritz, & Jelinek, 2011; Pole, 2007). In a recent meta-analysis of 58 studies on the psychophysiology in PTSD, Pole (2007) found that adults with PTSD (mostly males with military trauma) have higher resting arousal across all psychophysiological measures, with the most robust correlates of PTSD broadly being HR (in all study types), facial EMG (in idiographic trauma cue studies), and skin conductance habituation slope (in startle studies). Further, Pole (2007) found that baseline heart rate was the most robust of the psychophysiological indices associated with PTSD (with small unweighted ($r = .20$) and weighted ($r = .18$) median effect sizes, converted from d to r). Similarly, an earlier meta-analysis of 34 psychophysiological PTSD studies concluded that higher resting HR clearly distinguished patients with PTSD from healthy controls (Buckley & Kaloupek, 2001).

One common explanation for elevated heart rate in PTSD patients is a hyperactive SNS, thought to be altered by chronic psychophysiological hyperreactivity (Buckley & Kaloupek, 2001), which is consistent with self-reports of heightened psychophysiological arousal and reactivity in most PTSD patients. However, there is also evidence to suggest that elevated resting HR in PTSD is a result of deficits in parasympathetic activity rather than overactive sympathetic activity (e.g., Hopper, Spinazzola, Simpson, & van der Kolk, 2006). Heart rate is regulated by both the SNS and the PNS, indicating that overactivity of the SNS, withdrawal or hypoactivity of the PNS, or both, could be responsible for elevated heart rates (Berntson, Cacioppo, & Quigley, 1993). Thus, indices that distinguish PNS from SNS activity, such as heart rate variability (HRV), are needed to clarify the roles these two autonomic functions play in PTSD broadly and emotional numbing specifically.

HRV is a well-established index of parasympathetic influence on the heart via the vagus nerve (Porges, 2011; Thayer & Lane, 2000). HRV is measured by calculating the time intervals between individual heartbeats, from which two different types of scores are derived that indicate variability in the spacing between heartbeats (i.e., time domain measures and frequency domain measures, with high-frequency HRV indicating greater parasympathetic tone than low-frequency HRV). It is known that HRV is diminished in anxiety disorders generally; a recent meta-analysis of 36 studies examining HRV in anxiety disorders (including PTSD) concluded that overall, anxiety disorders are associated with reduced high frequency HRV (with small to moderate effect size of .44; Chalmers, Quintana, Abbott, & Kemp, 2014). Similarly, several studies looking at PTSD specifically have found lower resting HRV in individuals with PTSD as compared to trauma-exposed controls without PTSD (e.g., Blechert, Michael, Grossman, Lajtman, & Wilhelm, 2007).

There is some initial evidence that HRV may be suppressed in combat veterans with PTSD (Tan et al., 2009). In a recent study using a large sample (nearly 2,500) of active-duty marines, lower levels of high-frequency HRV were associated with a diagnosis of PTSD, with small effect sizes, with Cohen's *d* ranging from .21 to .24 (Minassian et al., 2014). Further, compared to marines with no prior experience, those marines with prior deployment experience showed suppressed resting HRV. However, in both of these studies finger-pulse recordings were used to approximate HRV rather than direct ECG recordings. Hauschildt and colleagues (2011) found that participants with PTSD (compared both to trauma-exposed and non-exposed controls) showed persistently low HRV across a number of different videos (i.e., neutral, negative, positive, and trauma-related). Another recent study that examined HR and HRV in a small sample of PTSD patients and trauma-exposed controls ($n = 35$), found that compared to controls, PTSD patients exhibited sustained increased HR (i.e., tachycardia) and attenuated HRV that failed to "recover" after exposure to a trauma-related prime (Norte et al., 2013). It has even been suggested that chronic tachycardia and reduced HRV may be linked to the robust findings that individuals with PTSD are at increased risk for developing cardiovascular disease (Dedert, Calhoun, Watkins, Sherwood, & Beckham, 2010; Thayer, Åhs, Fredrikson, Sollers, & Wager, 2012). The modulation of both cardiac parameters (i.e., HR and HRV) throughout the literature suggests the importance of deficient vagal control of the heart in PTSD patients, and therefore these may be critical to understanding emotional numbing.

Emotional numbing and social functioning. The relationship of emotional numbing to social functioning in PTSD has not been clearly elucidated, but may provide useful information about the persistence of PTSD over time. In fact, these two concepts are both included in the traditional 3-symptom diagnostic definition of emotional numbing, which includes: a restricted range of affect, feelings of detachment or estrangement from others and markedly diminished interest in significant activities. It is still unknown how emotional numbing is precipitated and maintained; it may be a result of pre-existing vulnerabilities (e.g., emotion dysregulation; an insecure attachment style), a direct result of traumatic events, a result of post-traumatic problems like social withdrawal, or any combination of these and other factors. One approach to understanding the relationship between emotional numbing and social difficulties is Hobfoll's (1989) concept of a *loss spiral*, in which an individual who already has limited resources is unable to effectively cope with the losses resulting from a traumatic experience, which leads to further loss. In the case of social functioning, a lack of pre-existing social support might contribute to the development of PTSD after a traumatic event occurs, which might in turn result in chronic emotional numbing symptoms, which might further impair social relationships and lead to losses of relationships and social support. Thus, identifying patterns of social functioning associated with emotional numbing might highlight potential targets for intervention.

As suggested above, impaired social functioning may be a mechanism by which emotional numbing contributes to chronic PTSD. Schnurr et al., (2004) independently examined factors associated with the development versus the maintenance of PTSD, and found that lower levels of both current social support and "emotional sustenance" were associated with chronic PTSD. Similarly, one meta-analysis that aimed to identify risk factors for the development of PTSD (Brewin, Andrews, & Valentine, 2000) found medium to strong effect sizes for the impact of current and post-trauma social support, which was stronger for military samples (r = .43) than for civilian samples (r = .30).

Researchers in the field of PTSD have long been aware that male veterans with war-zone related trauma commonly suffer with interpersonal difficulty (Nezu & Carnevale, 1987; Roberts et al., 1982). Men with PTSD from combat-trauma compared to other types of traumas are significantly more likely to be divorced and engage in spousal abuse (Prigerson et al., 2001). Over 70% of Vietnam veterans with PTSD reported clinically significant levels of relationship stress as compared to 30% of Vietnam veterans without PTSD (Riggs, Byrne, Weathers, & Litz, 1998). One possible reason for the higher degree of relationship distress among veterans with PTSD is that emotional detachment and reactivity (e.g., anger) may interfere with maintaining healthy relationships. For instance, Riggs and colleagues (1998) suggested that emotional numbing may directly interfere both with pair bonding and conflict resolution, among other essential relationship processes. It has also been shown that self-reported emotional numbing and anger are correlated with partner abuse (both physical and psychological/emotional abuse) in couples where one partner is a veteran with PTSD (Gavlovski & Lyons, 2004).

Several studies have examined attachment style in trauma-exposed veterans, consistently demonstrating positive associations among measures of insecure attachment and PTSD symptoms (e.g., Forbes, Parslow, Fletcher, McHugh, & Creamer, 2010; Franz et al., 2014; Ghafoori, Hierholzer, Howsepian, & Boardman, 2008; Nye et al., 2008). In a longitudinal design using data from the Vietnam Era Twin Study of Aging (Kremen, Franz, & Lyons, 2013), Franz et al. (2014) found that anxious and avoidant attachment measured at age 55 predicted PTSD symptoms at age 61, with medium effect sizes. Insecure attachment also significantly mediated the persistence of PTSD symptoms over time, such that symptom severity increased based on previously measured attachment insecurity. Based on mediation analyses, the authors proposed that one pathway through which PTSD symptoms become chronic is indirectly through their influence on attachment insecurity. It is also possible that as compared to securely attached people, individuals who are insecurely attached perceive events in their environment as more stressful, thus heightening chronic stress and contributing to vulnerability for developing PTSD. Consistent with findings from Franz et al. (2014), Besser and colleagues (2009) examined attachment insecurity in a sample of Israeli civilians exposed to chronic (7 years of) terrorist attacks, finding that trauma-exposed participants reported higher levels of anxious attachment than non-exposed controls. Furthermore, attachment anxiety was significantly associated with Cluster C avoidance/numbing symptoms, raising the question of whether and to what extent emotional numbing may also be related to other attachment dimensions, such as attachment-related avoidance.

Theoretically, emotional numbing and associated dysfunction (e.g., feelings of detachment, intensified anger) could interfere significantly with maintaining secure attachments, as well as make it difficult to feel empathy and compassion for others (Tone & Tully, 2014). However, very few studies have empirically examined the relationship between emotional numbing and relational functioning (Besser et al., 2009; Gavlovski & Lyons, 2004; Riggs et al., 1998), and those that have used either a broad Cluster C avoidance/numbing score or a composite of the three numbing symptoms (that included feeling withdrawn from others), thus conflating the two constructs. The use of more sensitive measures of emotional numbing in future studies would enable a better understanding of its relationship with social functioning.

Compassion Training as a Novel Intervention for Residual PTSD Symptoms

The following sections of this literature review focus on a novel potential approach to address residual emotional numbing in veterans who do not fully recover following first-line psychotherapeutic treatment. Nonresponse rates as high as 50% have been reported in empirically-supported treatment studies (Schottenbauer, Glass, Arnkoff, Tendick, & Gray, 2008). To this point, there is a lack of available approaches to sufficiently address emotional numbing and few alternative or complimentary interventions have been tested (Bormann, Thorp, Wetherell, Golshan, & Lang, 2013).

Theoretical support. In considering potential approaches to addressing residual emotional numbing, it is important to first identify which intervention targets are likely to be the most relevant. It has been shown that chronic PTSD is related primarily to factors that occur during and after the event, such as lack of social support (Brewin et al., 2000; Schnurr et al., 2004), suggesting that interventions geared toward increasing social connection may be particularly helpful. Another potential intervention target thought to promote chronic PTSD, as proposed by Ehlers and Clark (2000), is a cognitive processing style that continually reinterprets past traumatic material as a persistent threat. Thus, alternative interventions that directly address dysfunctional cognitive patterns could be especially useful. Lastly, it has been cogently argued that treatments for chronic PTSD must emphasize increasing body awareness and tolerance of interoceptive sensations in order to effectively promote healing from emotional and social dysfunction (Van Der Kolk, 2006). Based on this premise, interventions that target self-awareness and tolerating feelings and sensations, such as meditation practices, may also be well suited to addressing chronic emotional numbing.

Several researchers have recently piloted programs designed to increase self-awareness using alternative/complimentary interventions (Bormann et al., 2013; Tan, Dao, Farmer, Sutherland, & Gevirtz, 2011). In a small sample of 20 combat veterans randomized to either treatment as usual (TAU) or TAU plus an 8-week HRV biofeedback intervention, Tan et al. (2011) found that HRV biofeedback plus TAU resulted in significant reductions in the emotional numbing/avoidance cluster symptoms. Bormann and colleagues (2013) also used a prospective, random-assignment design in a larger sample (136) of veterans with chronic PTSD to test the impact of a 6-week, group meditation-based “mantram” (i.e., sacred word) intervention. Veterans randomized to the mantram meditation group showed significantly greater reductions in hyperarousal symptoms and the three emotional numbing symptoms of Cluster C. Taken together, these findings provide preliminary support for further studies piloting novel, self-awareness based interventions for emotional numbing. Neither of these studies, however, examined direct effects on social disconnection, which co-occurs with emotional numbing and may play a crucial role in maintaining residual PTSD symptoms.

CBCT is a secular meditation training intervention taught in a group-format that is designed to cultivate compassion for self and others. Compassion has been defined as the recognition of suffering accompanied by the heartfelt desire to alleviate that suffering (Goetz, Keltner, & Simon-Thomas, 2010; Gyatso, 2001). Compassion is a positive affective state and has been considered a “moral emotion” (Ozawa-de Silva et al., 2012) that can be increased with training (Condon et al., in press; Jazaieri et al., 2012; Mascaro et al., 2013). “Self-compassion” is essentially compassion applied to oneself: clearly recognizing one’s own suffering (e.g., negative thoughts; afflictive emotions) and its origin, and generating the genuine wish to free oneself from it. CBCT is designed to systematically develop self-compassion as well as compassion for others, by gradually enhancing positive feelings of connectedness to others and minimizing feelings of isolation and alienation (see Procedures and Table 1 for details of protocol). Over the course of the group training classes, participants start by practicing mindful awareness of the body breathing in order to learn how to focus their attention intentionally. From this basis of attentional stability, participants are guided through open awareness practices in order to gain insight into their own cognitive and emotional patterns. After increasing awareness of their own physiological and emotional states, participants practice generating self-compassion based on repeatedly seeing the destructive cognitive and emotional patterns that promote their distress. From the foundation of self-compassion, participants practice generating compassion for others, based on intentionally shifting their perspectives on close others, then strangers, and then difficult people in their lives. This final step focuses heavily on the interconnections between people and increasing one's sense of connection with all others. Therefore, as a whole, CBCT is theoretically designed to specifically target three processes that are thought to play a central role in chronic PTSD, and potentially in emotional numbing: awareness of sensations and emotions, dysfunctional cognitive patterns, and social connection deficits.

Empirical support. A large body of research has shown that engagement in meditation and other spiritual practices changes the brain and body in measurable ways. Lazar and colleagues (2005) demonstrated that meditation practice is associated with increased thickness of the cerebral cortex. Previous research testing CBCT has shown that individuals who practiced CBCT for 8 weeks increased their performance on an empathic accuracy test and showed greater activation in brain regions associated with empathy (Mascaro et al., 2013). Empathic accuracy is a skill that predicts relationship quality and is deficient in PTSD samples (Schmidt & Zachariae, 2009). CBCT has also been shown to improve inflammatory functioning (Pace et al., 2009), which is dysregulated in PTSD (Gill, Saligan, Woods, & Page, 2009).

It has also been shown that such individuals exhibit healthier psychological and psychophysiological responses to stressful situations following training in CBCT (Pace et al., 2009). Desbordes et al. (2012) demonstrated that CBCT practitioners showed altered activation patterns in the amygdala, a brain region associated with strong emotions such as anger, in response to emotional stimuli even while they were not meditating. This evidence in the context of the theoretical foundations of CBCT suggest that it could be a promising new approach that would target both the psychophysiological (e.g., HRV) through the process of formal meditation practice, as has been shown in other studies (e.g., Krygier et al., 2013), and the social-emotional dysfunction (e.g., through perspective shifting and compassion training) present in chronic PTSD.

Research Aims and Hypotheses

Based on the preceding review, the present study sought to investigate a currently understudied phenomenon, namely reports of emotional numbing in veterans with trauma histories. The aims of the study were four-fold:

I. To investigate the relationship between the most commonly used index of emotional numbing in PTSD (ratings of three Cluster C numbing symptoms) and a relatively new, more comprehensive measure of emotional numbing that might be more sensitive to change.

II. To better characterize the phenomenon of emotional numbing in PTSD by describing its relationships with a range of psychophysiological, emotional, and relational variables in a sample of male veterans with trauma histories reporting a range of PTSD symptoms.

2a) Self-reported emotional numbing symptoms were expected to be negatively associated with heart-rate variability (HRV) measured during resting baseline and emotional stimuli conditions, and positively associated with heart rate (HR) during baseline and stimuli conditions.

2b) Self-reported emotional numbing symptoms were expected to be positively associated with self-reported arousal in response to negative photographs and negatively associated with self-reported arousal in response to positive photographs.

2c) Self-reported emotional numbing symptoms were expected to be positively associated with self-reported attachment insecurity. For those veterans in romantic relationships, self-reported emotional numbing symptoms were expected to be negatively associated with relationship quality.

2d) Self-reported emotional numbing symptoms were expected to be negatively associated with self-reported compassion for self as well as others.

III. To determine the extent to which Cognitively-Based Compassion Training (CBCT) was feasible and perceived as a credible and acceptable intervention by veterans with a history of PTSD and current residual emotional numbing symptoms.

3a) Credibility, motivation, and satisfaction ratings (completed at baseline and post-intervention) would indicate that CBCT is credible and acceptable to veterans.

3b) Engagement measures (i.e., home meditation practice reports, retention rates, and attendance) would indicate that CBCT is an acceptable and feasible intervention for combat veterans with PTSD.

IV. To examine pre-post changes on outcome measures following CBCT. Participation in CBCT was expected to be associated with increased subjective feelings of compassion for self and others, and with improved relationship quality, reflecting the nature of the intervention; if so, changes in compassion were expected to be associated with changes in emotional numbing and other PTSD symptoms.

4b) Self-rated measures of compassion for self and compassion for others were expected to increase from baseline to post-CBCT.

4c) Relationship quality scores by self- and partner-report were expected to increase from baseline to post-CBCT.

Method

Participants and Procedures

This dissertation was part of a parent project designed to investigate immunological biomarkers associated with emotional numbing, as well as the potential impact of CBCT on emotional numbing symptoms, social connectedness, and empathic accuracy. The protocol described here includes the general procedures of the parent study, as well as procedures specific to the dissertation, both of which were approved separately by the Emory University institutional review board. Veterans were recruited from the Atlanta community by posting IRB-approved notices on physical and electronic bulletin boards, contacting clinicians specializing in veteran populations for referrals, and via Facebook advertisements linked to a study-designed website describing the eligibility criteria and study contact information. Interested veterans were screened by phone and if eligible, scheduled for a baseline assessment. Of those who were scheduled for the baseline assessment, those who were also eligible to enroll in the CBCT course (see eligibility criteria below) were offered the option to participate.

During the initial phone-screening interview, interested veterans were assessed for history of psychiatric diagnoses and basic inclusion/exclusion criteria, including information about prescription and non-prescription medications. Primary inclusion criteria included: (a) male veterans between the ages of 25 and 75, (b) combat exposure or traumatic military experience during deployment outside of U.S. territory, (c) a previous PTSD diagnosis and presence of emotional numbing was required only in order to participate in the CBCT course. Since there is a high rate of comorbidity with other forms of psychopathology in PTSD samples (e.g., Zlotnick et al., 2004), exclusion criteria were limited to the following, which might compromise ability to participate and/or interfere substantially with the quality of the data being collected: (a) self-reported psychotic symptoms or active suicidal ideation within the past six months, (b) self-reported active alcohol or drug abuse within the past six months, (c) self-reported depression serious enough to require hospitalization, or that resulted in a suicide attempt, within the last six months, (d) any change in self-reported use of psychotropic medication, including antidepressants, mood stabilizers, antipsychotics or chronic benzodiazepine therapy, over the past 6 weeks. Stable medication use was not an exclusion criterion because medication use is typical in this population.

If determined eligible after the phone screening, participants were scheduled for their baseline laboratory assessment (i.e., Assessment 1). At Assessment 1, all participants provided written informed consent for the study and completed the baseline self-report measures in a laboratory room in the Emory psychology building. Assessment 1 measures took roughly 60 minutes. For CBCT participants only, the self-report battery was followed by a 10ml blood draw as part of the larger study in order to measure inflammatory gene signaling[1]. CBCT participants also completed an informal consent process in order to wear an Electronically Activated Recorder device (EAR) for two days following Assessment 1, which randomly recorded 50 second snippets of audio every 12 minutes, allowing for quantification of time spent with others. Next, all participants were assisted with placement of facial EMG and ECG electrodes (details described below), from which psychophysiological data was collected while they sat in a chair for a 5-minute resting baseline. Participants then completed empathic accuracy and emotional

[1] Because the study was underpowered to test the inflammation hypotheses, and in discussion with the funding agency, we have determined not to assay these samples at present.

processing (IAPS) tasks (described in detail below) while psychophysiological data collection continued. The average time to complete Assessment 1 was 2.5 hours. The CBCT cohort participants were compensated $90 for this assessment and the additional measures (i.e., EAR and blood draw). The baseline assessment cohort (i.e., Assessment 1 only, no CBCT class) participants were compensated $50.

Veterans who endorsed having a current romantic relationship were asked if their intimate partner or spouse would be willing to complete a brief self-report survey online. Partners of participants who expressed interest in participating in this portion of the study were emailed an online link to the questionnaires. Partners were compensated $15 for their time.

The second phase of the study involved only CBCT participants, who attended weekly 2-hour sessions of CBCT over the course of 10 consecutive weeks. After completion of CBCT, these participants were scheduled to return to the lab for a post-intervention assessment (Assessment 2), during which they completed exit interview questions regarding their experience in CBCT, along with the same self-report assessment battery, blood draw, laboratory tasks, and psychophysiological measures that were completed at Assessment 1[2]. CBCT cohort participants received $90 for Assessment 2. Participants were not paid for attending CBCT classes. Classes were co-taught by the author (female) and another certified CBCT teacher (male) in the 1599 Clifton Road Building, roughly one mile from the location of the laboratory assessments.

Measures

Baseline self-report measures

All veterans completed a battery of self-report measures that included questions about PTSD symptoms, sleep disturbance, depression and anxiety symptoms, relationship quality,

[2] CBCT participants also wore the EAR for two days following Assessment 2.

personality traits, and substance use. Only the measures used for analyses in this dissertation are described in detail below.

Emotional numbing and PTSD symptoms were measured by the PTSD Checklist (PCL) (Blanchard, Jones-Alexander, Buckley, & Forneris, 1996), the PTSD Symptom Scale (PSS), and the Emotional Reactivity and Numbing Scale (ENRS; Orsillo et al., 2007). The PCL is a 17-item questionnaire that assesses the level of distress caused by PTSD symptoms, with each item rated on a 5-point Likert scale with anchors ranging from "Not at all" to "Extremely," and a total symptom severity score that can range from 17 to 85. The PCL is one of the most heavily utilized and cited self-report measures of PTSD symptomatology and has been shown to have strong internal consistency, test-retest reliability, and convergent validity with the Clinician-Administered PTSD Scale and Mississippi Scale (Blanchard et al., 1996; Keen, Kutter, Niles, & Krinsley, 2008). The PCL was used in this study to measure PTSD symptoms broadly, to calculate the Cluster C Numbing composite score, and to screen potential CBCT participants for emotional numbing and social disconnection symptoms. The Cluster C composite score was calculated by computing the mean of the following PCL items, consistent with DSM-IV Cluster C numbing symptoms: Item 9 (markedly diminished interest in previously enjoyable activities); Item 10 (feelings of detachment or estrangement from others); Item 11 (restricted range of affect or being unable to feel loving emotion toward close others). In order to be eligible for the CBCT classes, participants needed a minimum average score of 3.5 on the composite score at the time of the phone screening. The PSS is a self-report measure that assesses history and type of traumatic events, PTSD symptom presence and severity, and functional impairment. In this study the PSS was used to approximate number and type of lifetime traumatic events (Foa, Riggs, Dancu, & Rothbaum, 1993).

To include a more sensitive, continuous measure of emotional numbing, the ERNS was administered to all participants at Assessment 1 and to CBCT-participants at Assessment 2. The ENRS is a 62-item self-report questionnaire that measures emotional numbing and emotional reactivity, based on current theory and research on emotional functioning in PTSD. Items on the ENRS contribute distinctly to one of five subscales: General Numbing[3] (e.g., "I feel like I am emotionally numb"), Positive (e.g., "I feel affection during special moments with my family"), Sad (e.g., "I feel sad when I don't get something I really want and deserve"), Fear (e.g., "I feel somewhat nervous in new, unfamiliar situations"), and Anger ("I get really annoyed when someone hassles me"). Items are rated on a 5-point Likert scale anchored from "Not at all typical of me" to "Entirely typical of me." Emotional numbing symptoms were quantified by calculating mean scores for each of the five subscales. Initial reports demonstrate good internal consistency (subscale Cronbach alphas range from .81 to .91), test-retest reliability (correlations ranging from .72 to .87), and discriminant validity. In our sample, the ERNS had good internal consistency across the five subscales as measured by Cronbach's alpha: .78 for General Numbing, .89 for Positive Numbing, .75 for Sad Numbing, .73 for Fear Numbing, and .75 for Anger Numbing.[4] Following Bennett et al. (2015), all ERNS subscales were rescored so that higher scores on each subscale indicated higher numbing.

Feigning/Accuracy of symptoms was evaluated using the Negative Distortion Scale (NDS) of the Personality Assessment Inventory (PAI). The NDS is a 15-item, Likert-scale questionnaire that is often utilized to help determine whether an individual is honestly reporting

[3] Note that the General Numbing subscale does not reflect a total ERNS score, but rather general numbing to the full range of emotional experiences.

[4] Due to clerical error, the first 16 participants were administered only 36 of the 62 total ERNS items. 36-item scores were highly correlated with 62-item scores (*r's* ranged from .91 to .99). Thus, 36-item ERNS scores for the full sample were computed and used in all analyses in order to maximize power to test hypotheses.

psychiatric symptoms. Thomas et al. (2012) determined that using an NDS cut-off score of 85*T* correctly classified 97% of participants with genuine PTSD and 64% of feigners. Thus, for the CBCT classes only, participants needed a maximum T score of 85 on the NDS to be eligible.[5]

Attachment style was measured by The Experiences in Close Relationships-Revised Questionnaire (ECR-R; Fraley, Waller, & Brennan, 2000), a 36-item self-report scale designed to measure individual differences in attachment-related avoidance and attachment-related anxiety in adults. Items are rated on a 7-point Likert scale from 1 ("Strongly Disagree") to 7 ("Strongly Agree") and address a number of general experiences in emotionally intimate relationships (e.g., "When my partner is out of sight, I worry that he or she might become interested in someone else," "I prefer not to show a partner how I feel deep down"). The ECR-R is scored on two dimensions: Avoidance (i.e., discomfort with closeness and depending on others) and Anxiety (i.e., fear of abandonment or rejection). The ECR-R has a clear two-factor structure, high internal consistency, and adequate short-term temporal stability (i.e., over a 6-week period; Fraley et al., 2000; Sibley & Liu, 2004). In our sample, the ECR-R had excellent internal consistency, with Cronbach alpha coefficients of .92 and .93 for the Anxiety and Avoidance subscales, respectively.

Relationship Quality was measured by administering the following scales both to veterans and their romantic partners (if they had a partner or spouse who was willing to participate): The Revised Dyadic Adjustment Scale (RDAS; Busby, Crane, Larson, & Christensen, 1995) and the Intimacy Scale of the Sternberg Triangular Love Scale (STLS;

[5] With the exception of one baseline assessment participant, all veterans had an NDS score below T=85. Although this was not an exclusion criterion for the baseline assessment cohort, all analyses were performed both with and without this individual to check for undue influence. Effect sizes and alpha values did not change based on his inclusion/exclusion, with the exception of one non-primary analysis. Given the rationale above coupled with recent evidence that that feigning/overreporting of PTSD symptoms does not attenuate the relationship between HRV and PTSD symptoms (Brady et al., 2015), this individual participant was included in all analyses reported here.

Sternberg, 1997), one of three subscales in the STLS that measures intimacy in close personal relationships. The Intimacy Scale is made up of 12-items rated on a 9-point Likert scale, with higher mean scale scores indicating greater relationship intimacy. In our sample, Cronbach's alpha was .92, indicating excellent internal consistency. The RDAS is a 14-item questionnaire that assesses relationship quality in romantic relationships within three overarching categories: Consensus, Satisfaction, and Cohesion. Overall sum scores on the RDAS range from 0 to 69, with higher scores indicating greater relationship satisfaction. Scores of 47 and below indicate relationship distress. Cronbach's alpha was .80, indicating good internal consistency.

Compassion for self and for others was measured by the Self-Compassion Scale (SCS; Neff, 2003), the Compassionate Love of Close Others Scale (CLCOS), and Compassionate Love of Humanity Scale (CLOHS; Sprecher & Fehr, 2005). The SCS is a 26-item scale designed to measure three components of self-compassion: mindfulness (versus over-identification), self-kindness (versus self-judgment), and common humanity. The SCS has good reliability and discriminant validity with related but distinct constructs (e.g., self-esteem). Items are rated on a Likert scale from 1-5 and make up six distinct subscales to measure the components of self-compassion. Overall SCS scores are calculated by reverse coding the self-judgment, isolation, and over-identification items and then summing the means of all six subscales. In our sample, the overall SCS had excellent internal consistency (Cronbach's alpha = .94) and the six subscales had good internal consistency (Cronbach's alpha coefficients ranged from .79 to .85).

The CLCOS and CLOHS are 21-item scales designed to measure feelings of compassionate love toward close others and strangers, respectively. Compassionate love is defined as an attitude toward close others that involves behavior, feeling, and thinking that is all focused on caring, concern, tenderness, and an orientation toward supporting, helping, and understanding the others, particularly when the others are perceived to be suffering or in need. The final scores are calculated by computing an average for all 21 items. Due to clerical error, item 17 of the CLCOS was not presented to 87% of participants, thus we omitted this item for every participant in computing the overall mean score. In our sample, the CLCOS had excellent internal consistency, with a Cronbach's alpha of .95 and the CLOHS had excellent internal consistency, with a Cronbach's alpha of .97.

Psychophysiological measures and laboratory tasks

Psychophysiological Recordings (Electrocardiology and Facial Electromyography[6]). After veterans completed the questionnaires (and blood draw for the CBCT cohort), an experimenter placed 4-mm (sensor diameter) Ag/AgCl electrodes filled with conductive adhesive gel over participants' left lateral frontal, corrugated, and zygomatic facial muscles. Veterans were then assisted to place 11-mm Ag/AgCl electrodes on both sides of their rib cage and under the right collarbone. During a 5-minute resting baseline subsequent emotional processing tasks, a Biopac MP150 Data Acquisition System was used to measure electrocardiologic (ECG) data and electromyography (EMG) of the facial muscles, which inputted the data to Acq*Knowledge*, a software program that provides voltage output reflecting heart rate and interbeat interval for ECG, and microvolts for EMG. Heart-rate variability (HRV) and heart rate (HR) were initially calculated from the continuous ECG sampling data for distinct time periods of the laboratory assessment including a 5-minute resting baseline and subsequent emotional stimuli conditions. These HR and HRV parameters were averaged values that were automatically computed for each of the six time periods by the AcqKnowledge software, based on the millisecond intervals between successive R waves per the recommendations of the Task Force of the European Society of Cardiology the North American Society of Pacing and Electrophysiology (1996). Of the

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[6] Measure is part of the larger study; is not included in dissertation.

frequency-domain variables calculated by AcqKnowledge, High Frequency HRV (HF-HRV) was selected because it provides a reliable estimate of parasympathetic (vagal) output (Porges, 1997, 2011) and is the most frequently reported measure of HRV in the anxiety literature. As is customary when analyzing HRV data, HF-HRV raw scores (in ms^2/Hz) were corrected by log transformation because they were non-parametrically distributed (van Zyl, Hasegawa, & Nagata, 2008). HR was calculated as beats per minute. All raw ECG data files were checked for artifacts, such as irregularities in the ECG wave caused by movement, and edited by hand in AcqKnowledge as necessary. Sporadic arrhythmias were not edited. Veterans were asked to sit quietly and to avoid moving excessively during this portion of the procedure due to continuous sampling of psychophysiological data. Due to equipment failure, adequate psychophysiological data was not collected from three participants.

Emotional Processing Tasks. Following the 5-minute baseline, participants completed an empathic accuracy task (a main measure in the parent study, but not analyzed for this dissertation). During this task, video stimuli depicting real people describing negative and positive autobiographical events (e.g., losing a loved one; going on a meaningful trip) were presented on a computer screen (see Kern et al., 2013; Zaki, Weber, Bolger, & Ochsner, 2009). The target people used in this task were originally videotaped while telling stories, then later re-watched their videos and continuously rated their affective state moment by moment with the use of a sliding 9-point Likert scale, anchored from "very negative" on the left and "very positive" on the right. They were instructed to concentrate on the affect they had felt while discussing events (i.e., during the videotaping) rather than during the occurrence of the events themselves.

Veterans in the present study watched these stimulus videos while seated in front of a computer desk in the lab, and were instructed in how to use two keyboard buttons to continuously rate how positively or negatively they believed the target person in the video felt at each moment during the autobiographical story, using the same 9-point scale that the targets themselves had used (anchored with very negative on the left and very positive on the right). Participants were carefully instructed to rate how they believed the targets felt at each moment while talking about events.

Next, veterans were asked to sit in front of a computer screen in a laboratory setting while images from the International Affective Picture System (IAPS) were presented for 6s each. After each image presentation, participants were asked to rate their emotional responses on the dimensions of valence and arousal using a 9-point Self-Assessment Manikin (SAM; Bradley & Lang, 1994), which ranged either from “very pleasant” to “very unpleasant” (valence) or “very calm” to “very activated” (arousal). All pictures depicted various scenarios, with equally distributed numbers of positive, negative, or neutral images (based on emotional valence and arousal ratings drawn both from the published norms for adult males and norms for Vietnam veterans; Lang, Bradley, & Cuthbert, 2005; Wolf, Miller, & McKinney, 2009). Wolf and colleagues (2009) reported a high degree of consistency between Lang’s published IAPS norms from a male undergraduate sample and norms from their sample of male veterans’ ratings (both with and without PTSD).

Positive images depicted scenes such as happy babies, smiling couples, adventure scenes, and nude females or couples. Neutral images depicted scenes such as a neutral male face or a generic landscape, and negative images depicted threatening or sad situations, such as a starving woman or scenes from natural disasters. Within the negative and positive categories, pictures were divided into subsets of low and high arousal (e.g., “Hi Positive” vs. “Low Positive”). A total of 115 images were presented, in 5 blocks of 23 images, with each block lasting roughly 4 minutes and 45 seconds, in the following order: neutral images (Neutral), low-arousing negative images (Low Neg), high-arousing positive images (Hi Pos), high-arousing negative images (Hi Neg), and low-arousing positive images (Low Pos). Before the stimulus images were presented, participants were told that they would be seeing a number of photographs ranging in emotional content, and that their task was simply to watch and respond naturally to the images. Mean self-reported arousal scores were calculated for each image block by averaging arousal ratings across each set of 23 images.

Credibility, motivation, acceptability, and engagement with CBCT

Credibility was measured at pre- and post-intervention using a 5-item, study-designed intervention rating form designed to assess CBCT's credibility in the eyes of participants. The first four items were rated on a 9-point Likert scale ranging from 1 (not at all) to 9 (very much); the last item pertained to expected symptom improvement on a scale from 0-100%, converted later to 0-10. Therefore, possible scores on this measure ranged from 4 to 9.2 (higher scores indicating greater credibility). Items were drawn and adapted from Borkovec and Nau (Borkovec & Nau, 1972) and Devilly and Borkovec's (1972) credibility and expectancy measures for psychotherapeutic interventions (e.g., "How logical does this type of program seem to you?" "How confident would you be that this program would be successful in helping you feel more connected to others and less emotionally numb?" "How successful do you feel this program would be in improving well-being more generally?").

Motivation to engage in CBCT was measured at pre-intervention only using a 10-item study-designed motivation rating form. Items were drawn and adapted from the Treatment Motivation Questionnaire (TMQ; Ryan, Plant, & O'Malley, 1995) in order to measure four distinct motivational categories: internal motivation, external motivation, help seeking motivation, and confidence in CBCT. Items pertaining to each of these four categories were averaged together to compute a mean score for each category. Items were rated on a 7-point Likert scale ranging from 1 (not at all true) to 7 (very much true), and preceded by the prompt, "I enrolled in this study because…" (e.g., "I want to make changes" "I was pressured to come" "It will be a relief to share my concerns with others" "I accept the fact that I need help and support" "I am not sure this meditation program will be helpful for me").

Acceptability and engagement was measured based on attendance at weekly sessions, completion of assigned at-home meditation practice, and participant satisfaction with CBCT. Participant satisfaction was measured using the 8-item self-report Client Satisfaction Questionnaire (CSQ-8; Attkisson & Zwick, 1982) administered at the end of the final CBCT class. The CSQ-8 is designed to yield a homogeneous estimate of general satisfaction with services, with scores ranging from 8 to 32 (higher scores indicating greater satisfaction). Participants also completed a written post-intervention exit interview to provide a qualitative assessment of participant satisfaction with CBCT. The exit interview included questions such as: "Has the meditation course been helpful to you?" "What would've been more helpful?" "What *wasn't* helpful?" "Would you recommend this course to another combat veteran with similar concerns? Why or why not?"

Over the course of each week, participants were asked to practice the meditations at home that corresponded with the content of the weekly session. Participants were asked to build up to 20-30 minutes each day of at-home practice and were provided with audio CDs and online recordings of guided meditations for each of the CBCT modules (see Table 1). Participants were asked to keep track of their meditation time and frequency daily on a meditation practice-log worksheet, and were asked to turn in the meditation worksheets from the previous week at the beginning of each class. Acceptability and engagement was measured by participant time spent in at-home practices, weekly attendance, and course completion rates. Consistent with other contemplative intervention studies (e.g., MBCT; Teasdale et al., 2000), participants were considered “completers” if they attended half (i.e., five or more) of the ten CBCT sessions and completed the post-intervention assessment (Assessment 2).

Intervention

CBCT. CBCT is a secular meditation training intervention taught in a group-format that is designed to cultivate compassion for self and others. The CBCT protocol consists of six distinct modules typically taught over the course of 8-10 weeks, which are described in detail in Table 1. The modules are taught in a stage-like fashion such that each module builds on the skills taught in the previous stages. First, participants learn how to cultivate focused attention through mindfulness practice and then learn to apply present moment awareness to gain insights into their own internal cognitive and emotional patterns. Next, participants practice generating self-compassion based on these insights and a growing determination to emerge from those cognitive and emotional patterns that promote unhappiness. From the basis of self-compassion, participants are led to extend the same insights to their perceptions of others in order to gain new perspectives on their relationships with close others, strangers, and difficult people in their lives. Over the course of CBCT, participants are led through a series of integrated, cumulative meditations – and provided with guided meditation recordings for each module – in order to systematically develop compassion. CBCT aims to enhance positive feelings of connectedness to others, while minimizing feelings of isolation and alienation.

Statistical Analyses

In order to examine the specificity of the five numbing subscales of the ERNS as compared to the Cluster C numbing composite score, we computed Pearson correlation coefficients among these variables (Aim 1). In order to test our hypothesis that self-reported emotional numbing symptoms would be negatively associated with HF-HRV and positively associated with HR (Aim 2), Pearson's correlations were first conducted to examine the direct, bivariate associations between the cardiac variables and the numbing subscales, which were followed with a series of mixed regression analyses accounting for image condition as a repeated within-subjects variable. With regard to image valence and intensity, mixed design ANOVAs with image condition as the within-subjects repeated measure and PTSD diagnosis as the between-subjects factor were conducted separately to examine whether HR and HF-HRV differed across the six conditions (Baseline, Neutral, Low Neg, Hi Pos, Hi Neg, Low Pos), and whether this relationship differed according to PTSD status. Lastly, we examined the relationship of psychophysiological arousal (i.e., HF-HRV and HR) to self-reported arousal using Pearson correlations and examined changes in self-reported arousal across image conditions using mixed design ANOVAs. Given that violations of sphericity assumptions in repeated measures ANOVA are common with psychophysiological data (Vasey & Thayer, 1987), significance of all effects are reported based on the Greenhouse-Geisser correction.

To examine patterns of associations between emotional numbing and self-reported arousal across image conditions (Hypothesis 2b), Pearson correlations were computed between self-reported arousal and numbing subscale scores for the five image conditions. To examine patterns of association between emotional numbing and hypothesized social/relational correlates (Hypotheses 2c and 2d), Pearson correlations were calculated between scores on the five numbing subscales and scores on the ECR-R subscales, the RDAS, and the three compassion measures (i.e., SCS, CLCOS, CLOHS).

Participant satisfaction and engagement were evaluated by examining the following variables descriptively: credibility, motivation, satisfaction, at-home meditation practice, retention rates, and attendance (Aim 3). To determine whether participation in CBCT was associated with decreased PTSD symptoms and emotional numbing (Aim 4), as measured by the PCL and five numbing subscales, respectively, paired sample t-tests were conducted to compare pre- and post-scores on the SCS, CLCOS, CLOHS, PCL, and numbing subscales. To test for the potential effect of engagement variables (i.e., meditation practice time and class attendance) and expectation variables (i.e., credibility, motivation, satisfaction), Pearson correlations were computed between engagement and expectation variables, and change scores for the SCS, CLCOS, CLOHS, PCL, and numbing subscales. Relationship measures were examined descriptively due to the small number of CBCT participants who were in a romantic relationship and the smaller number of couples who completed measures at both time points.

Results

Preliminary Analyses

For all correlational analyses, Spearman's rho correlations were computed between any variables that were non-parametrically distributed. Pearson's correlations were calculated to examine multicollinearity among the five numbing subscales. Correlation coefficients between subscales are shown in Table 3, which ranged from .06 to .54, with p values ranging from .72 to < .001. An alpha level of .05 was used to determine significance of all statistical tests.

To address potential effects of medications on the cardiac variables, participants were coded dichotomously as either: a) currently taking any medication, not including vitamins or allergy medications (n = 37) or b) *not* currently taking any medication (n = 10). Independent samples t-tests revealed no significant group differences in HR ($t(42) = 1.29$, p = .21) or HF-

HRV ($t(42) = 1.98$, $p = .054$). However, given the small sample size and the marginal significance of the difference between groups on HF-HRV, we conducted further analyses to explore the potential impact of medications that act directly on cardiac function and are known specifically to decrease heart rate. Participants were coded dichotomously as either: a) currently taking an anti-hypertensive or beta-blocker ($n = 20$) or b) *not* currently taking any anti-hypertensives or beta-blockers ($n = 27$). There were no significant differences in HR between participants who reported taking anti-hypertensives or beta-blockers ($M = 70.46$, $SD = 12.39$) and participants who did not ($M = 68.64$, $SD = 9.87$; $t(42) = .54$, $p = .59$). Similarly, there were no significant differences in HF-HRV between participants who reported taking anti-hypertensives or beta-blockers ($M = 1.76$, $SD = .53$) and participants who did not ($M = 1.72$, $SD = .69$; $t(42) = .22$, $p = .83$). To control for potential effects of medication use, anti-hypertensive/beta-blocker use was also included as a covariate in the mixed regression and mixed design ANOVA models (see Hypothesis 2a below). Age was also tested as a potential covariate of the cardiac variables; age was not significantly associated with either HR or HF-HRV (p values ranged from .29 to .82). Therefore, we did not include age as a covariate in analyses with cardiac variables. Participants with sporadic arrhythmias were identified and all HRV analyses were performed both with and without these individuals. Results did not change based on inclusion/exclusion of these participants, and thus they were included in all analyses reported here.

The Maximum Likelihood Estimation (MLE) approach to handling data missing at random (Dempster, Laird, & Rubin, 1977; Wu, 1983) was used to impute missing values for all self-report measures with missing data. MLE was only used when an item, measure, or individual participant had less than 20% missing data.

Participant Enrollment and Flow

We conducted phone screens with veterans who were referred to the study (i.e., by clinicians, flyers, the website, or other veterans) to determine initial eligibility (n = 73). Of these, seven veterans (9.59%) declined participation and 15 (20.56%) failed the phone screen, with lack of sufficient combat or military trauma experience or recent suicide attempt/hospitalization being the most frequent reasons for ineligibility. Of the remaining 51 veterans, 20 were eligible and willing to participate in the CBCT cohort (i.e., baseline assessment followed by 10 weeks of CBCT course and a final follow-up assessment); the other 31 were eligible and willing to participate in the baseline assessment only.

Figure 1 illustrates participant flow during the study using the CONSORT diagram. Two cohorts of 10 participants each were initially assigned to CBCT (n = 20). Among participants assigned to CBCT, eight discontinued during allocation; of these, the majority did not provide a reason and never attended any of the CBCT classes. One participant reported discomfort with disclosing personal information; the other seven did not give a reason and did not respond to repeated contact attempts by study personnel. The first CBCT cohort (n = 5) completed Assessment 1, 10-weeks of CBCT, and Assessment 2 between July and October of 2015, and the second cohort (n = 7) completed study procedures between February and May of 2016. In the second cohort, two additional participants discontinued the intervention (i.e., lost to follow up) and did not provide reasons. Among participants who were allocated only to the baseline assessment, three did not complete the assessment either via no-show or cancellation and failure to reschedule.

All participants were male veterans between the ages of 25 and 72, with a range of trauma histories and experiences. Of the 48 participants who attended the baseline assessment, one participant's data was excluded based on psychotic symptoms and suspected substance use evident at the time of the assessment. The final sample was 47 participants. Thirty-three (70%) of these participants reported having previously been diagnosed with PTSD at a VA hospital, and of these, 26 (79%) currently met full criteria. The remaining 14 (30%) participants had never meet criteria for PTSD. Of those participants reporting a previous PTSD diagnosis, 21 (64%) reported continued symptoms of emotional numbing and social disconnection (i.e., an average score of at least 3 on the DSM-IV emotional numbing symptoms). In the full sample, veterans reported having had 5.64 (*SD* = 2.44) traumatic experiences in their lifetimes (on the PSS).

Table 2 provides descriptive statistics for the sample (separately for the CBCT group and the baseline assessment group), including military experience and trauma exposure. Approximately half of participants were not currently in a relationship due to divorce, separation, never having married, or death of a spouse (51%). One-third of participants were married or cohabitating (34%), and the remaining participants were in a current relationship but not living together (15%). Approximately half of participants identified as African American (49%), 30% ($n = 14$) were Caucasian, and 21% ($n = 10$) self-identified in another ethnic category. CBCT participants ranged in age from 31 to 69 years old and had served in the Vietnam, Grenada, Afghanistan, and Iraq conflicts; one participant served multiple tours in both Afghanistan and Iraq, serving a total of 808 days in combat. Baseline assessment participants ranged in age from 25 to 72 and had served in a variety of military situations.

Hypothesis 1a: Associations Between Emotional Numbing Measures

Table 3 displays associations between each of the numbing subscale scores and the Cluster C numbing composite score. The composite score was significantly and positively associated with the General Numbing subscale score, $r(45) = .59$, $p < .001$, and the Positive

Numbing subscale score, $r(45) = .30$, $p = .04$. The composite score was not associated with Sad Numbing, Fear Numbing, or Anger Numbing subscale scores (p values ranged from .14 to .73).

Hypothesis 2a: Associations Between Emotional Numbing and Cardiac Variables

Associations between the numbing subscale scores and cardiac variables (i.e., HF-HRV and HR) are depicted in Table 4. HF-HRV was significantly and positively associated with emotional numbing scores on the General Numbing, Positive Numbing, and Sad Numbing subscales. HR was significantly and negatively associated with General Numbing and Positive Numbing scores. There were no associations between the Fear Numbing and Anger Numbing scores with either of the cardiac variables.

Mixed regression models of HF-HRV with image condition as a within-subjects factor and numbing scores as fixed effects were conducted to examine whether HF-HRV differed as a function of numbing subscale scores and image condition, while accounting for non-independence of repeated measures within subjects. All mixed regression models also included a covariate to account for potential influences of anti-hypertensive or beta-blocker medication use on HF-HRV, entered in as a fixed effect. The six image conditions included: resting baseline with no images presented, Neutral, Low neg, Hi Pos, Hi Neg, and Low Pos. Across all models tested, image condition was not a significant predictor of HF-HRV (F's ranged from .73 to .93, p values ranged from .60 to .47). Similarly, anti-hypertensive/beta-blocker use was not a significant predictor of HF-HRV in any of the models (β's ranged from -.02 to .08, p values ranged from .89 to .68). General Numbing was significantly associated with HF-HRV, $\beta = .29$, $t(40.93) = 2.58$, $p = .01$, indicating a positive relationship between general emotional numbing and heart rate variability. Positive Numbing was significantly associated with HF-HRV, $\beta = .39$, $t(41.01) = 3.07$, $p = .004$, indicating a positive relationship between numbing to positive emotions and heart rate variability. Sad Numbing was significantly associated with HF-HRV, $\beta = .27$, $t(41.06) = 2.03$, $p = .049$, indicating a positive relationship between numbing to sadness and heart rate variability. Fear Numbing and Anger Numbing were not significantly associated with HF-HRV, βs = .06 and .13, respectively. Figure 2 displays these relationships.

Mixed regression models of HR with image condition as a within-subjects factor and numbing scores as fixed effects were conducted to examine whether HR differed as a function of numbing subscale scores and image condition, while accounting for non-independence of repeated measures within subjects. All mixed regression models also included a covariate to account for potential influences of anti-hypertensive or beta-blocker medication use on HR, entered in as a fixed effect. Again, across all models tested, image condition was not a significant predictor of HR (*F*'s ranged from .63 to 1.59, *p* values ranged from .68 to .16), nor was anti-hypertensive/beta-blocker use (β's ranged from 1.28 to 2.57, *p* values ranged from .71 to .40). General Numbing was significantly associated with HR, $\beta = -4.37$, $t(40.72) = -2.23$, $p = .03$, indicating a negative relationship between general emotional numbing and heart rate. Positive Numbing was significantly associated with HR, $\beta = -7.41$, $t(40.60) = -3.45$, $p = .001$, indicating a negative relationship between numbing to positive emotions and heart rate. Sad Numbing, Fear Numbing, and Anger Numbing were not significantly associated with HR, βs ranged from -2.31 to .80. Figure 3 displays these relationships.

A mixed design ANOVA with image condition as the within-subjects repeated measure and PTSD diagnosis as the between-subjects factor was used to examine whether HF-HRV differed across the six image conditions and whether this relationship differed according to PTSD status. To account for potential influences of medication use on HF-HRV, use of anti-hypertensives or beta-blockers was entered into the model as the first between-subjects factor.

Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, $\chi^2(14) = 69.93$, $p < .001$, and therefore, a Greenhouse-Geisser correction was used. The main effect of image condition on HF-HRV was not significant, $F(2.44, 75.71) = .53$, $p = .76$, $\eta_p^2 = .02$, there was no interaction between image condition and anti-hypertensive/beta-blocker use, $F(2.44, 75.71) = 1.24$, $p = .30$, $\eta_p^2 = .04$, and there was no interaction between image condition and PTSD diagnosis, $F(2.44, 75.71) = .38$, $p = .73$, $\eta_p^2 = .01$. There was no main effect of anti-hypertensive/beta-blocker use on HF-HRV, $F(1, 31) = .08$, $p = .78$, $\eta_p^2 = .002$. There was a significant main effect of PTSD diagnosis on HF-HRV, $F(1, 31) = 5.13$, $p = .03$, $\eta_p^2 = .14$, with PTSD participants having higher heart rate variability across image conditions as compared to non-PTSD participants (Figure 4).

A mixed design ANOVA with image condition as the within-subjects repeated measure and PTSD diagnosis as the between-subjects factor was conducted to examine whether heart rate differed across the six image conditions, and whether this relationship differed according to PTSD status. To account for potential influences of medication use on heart rate, use of anti-hypertensives or beta-blockers was entered into the model as the first between-subjects factor. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, $\chi^2(14) = 45.39$, $p < .001$, and therefore, a Greenhouse-Geisser correction was used. The main effect of image condition on heart rate was not significant, $F(3.13, 97.09) = .98$, $p = .41$, $\eta_p^2 = .03$, there was no interaction between image condition and anti-hypertensive/beta-blocker use, $F(3.13, 97.09) = .71$, $p = .55$, $\eta_p^2 = .02$, and there was no interaction between image condition and PTSD diagnosis, $F(3.13, 97.09) = 1.30$, $p = .28$, $\eta_p^2 = .04$. There was no main effect of anti-hypertensive/beta-blocker use on heart rate, $F(1, 31) = .02$, $p = .90$, $\eta_p^2 = .001$. There was a significant main effect of PTSD diagnosis on heart rate, $F(1, 31) = 7.66$, $p = .01$, $\eta_p^2 = .20$, with

PTSD participants having lower heart rate across image conditions as compared to non-PTSD participants (Figure 5).

Next, we examined the relationship between psychophysiological arousal (i.e., HF-HRV and HR) and self-reported arousal, and assessed changes in self-reported arousal across the six image conditions. There were no significant associations between self-reported arousal and HR within each image condition. For self-reported arousal and HF-HRV, only Hi Neg arousal was significantly associated with Hi Neg HF-HRV, $r(35) = -.36$, $p = .03$; arousal ratings were not associated with HRV for Neutral, Low Neg, Low Pos, or Hi Pos. Mixed design ANOVA results indicated that there was a main effect of image condition on self-reported arousal, $F(2.33, 81.51) = 25.66$, $p < .001$, $\eta_p^2 = .42$, after using a Greenhouse-Geisser correction for violation of sphericity. The main effect of PTSD diagnosis was not significant, $F(1, 35) = 1.47$, $p = .23$, $\eta_p^2 = .04$, and there was no interaction between image condition and PTSD diagnosis, $F(3.17, 101.44) = 1.03$, $p = .39$, $\eta_p^2 = .03$. Post hoc Sidak tests to adjust for multiple comparisons indicated that self-reported arousal levels during Low Neg and Hi Neg were significantly different from each other ($p < .001$) and from all other image conditions (*p's* ranged from .01 to < .001). Self-reported arousal during the Neutral condition was not significantly different from arousal during Hi Pos or Low Pos. Figure 6 displays the main effect of image condition on self-reported arousal.

Compared to the IAPS male arousal norms for our entire set of images ($M = 4.49$, $SD = 1.21$), veterans in our sample reported significantly higher arousal overall ($M = 5.26$, $SD = 1.19$). While there were no significant differences between veterans' arousal ratings and the male arousal norms for the Low Pos and Hi Pos conditions (*p's* = .58 and .11, respectively), veterans rated the Hi Neg images as significantly more arousing ($M = 6.98$, $SD = .51$) than the IAPS male norm sample (*M* = 6.13, *SD* = .55; $t(42) = -5.33$, $p < .001$). Likewise, veterans rated both Low Neg images (*M* = 5.75, *SD* = .61) and Neutral images (*M* = 4.57, *SD* = .70) as significantly more arousing than did the IAPS male norm sample (Low Neg: *M* = 4.15, *SD* = .43; $t(42) = -10.10$, $p < .001$; Neutral: *M* = 2.97, *SD* = .51; $t(42) = -8.70$, $p < .001$).

Hypothesis 2b: Associations Between Emotional Numbing and Self-Reported Arousal

Overall, arousal ratings were not associated with emotional numbing scores. Hi Neg arousal was negatively and significantly associated with Sad Numbing, $r(38) = -.32$, $p = .046$. The associations between Hi Neg arousal and both Anger Numbing and Fear Numbing were in the negative direction, but were not significant, $r(38) = -.27$, $p = .09$, and $r(38) = -.28$, $p = .08$, respectively. The association between Hi Pos arousal and both Sad Numbing and Anger Numbing were in the negative direction but were not significant, $r(38) = -.27$, $p = .09$, and $r(38) = -.29$, $p = .07$, respectively. Likewise, the relationship between Lo Neg arousal and Fear Numbing was in the negative direction and did not reach significance, $r(39) = -.30$, $p = .06$.

Hypothesis 2c: Associations Between Emotional Numbing and Relational Functioning

Attachment Avoidance as measured by the ECR-R was significantly and positively associated with three of the numbing subscale scores: General Numbing, Positive Numbing, and Sad Numbing. Attachment Anxiety as measured by the ECR-R was significantly and positively associated with General Numbing and Positive Numbing scores, but negatively associated with numbing to Fear Numbing. Attachment Avoidance and Attachment Anxiety were significantly associated with one another, $r(45) = .41$, $p = .005$. For veterans who reported being in current romantic relationships, relationship quality as measured by the RDAS was significantly associated with General Numbing, such that veterans with higher numbing scores had lower

RDAS scores, indicating more relationship distress with their partners. Table 5 displays all Pearson correlations.

Hypothesis 2d: Associations Between Emotional Numbing and Compassion

Compassion for self and others, as measured by the SCS, CLCOS, and CLOHS, was significantly associated with scores on General Numbing, Positive Numbing, and Fear Numbing, such that higher emotional numbing was negatively associated with compassion for self and others. Sad Numbing was not associated with scores on the SCS, but was significantly and negatively associated with scores on the CLCOS and CLOHS. Anger Numbing was not significantly associated with any of the compassion measures. Pearson correlations are displayed in Table 6.

Overall self-compassion (SCS) scores were not significantly associated with scores on the other-compassion measures. However, Self-Kindness and Mindfulness subscale scores were significantly associated with the CLCOS, $r(43) = .31$, $p = .04$, $r(43) = .36$, $p = .02$, respectively, and Mindfulness and Common Humanity subscale scores were significantly associated with the CLOHS, $r(43) = .34$, $p = .02$, $r(43) = .36$, $p = .02$, respectively.

Hypothesis 3a: CBCT Engagement and Satisfaction

Of the 12 participants who started CBCT, 10 (83%) completed the intervention (as defined by attending at least five sessions), with an average of 7.90 ($SD = 0.99$) out of 10 sessions completed. Of the two participants who did not complete CBCT, reasons for discontinuation are unknown because participants did not respond to contact attempts from study personnel. One non-completer attended only one class session and the other attended only three sessions within the first four weeks and did not return or respond to contact attempts.

After attending the introductory class, participants reported that CBCT was a credible intervention on a 1 to 9 scale, $M = 7.73$, $SD = 1.05$, and expected a reduction of overall distress (e.g., stress levels, relationships, negative emotions, other symptoms) of 62.92% ($SD = 26.84$). On a 1-9 scale, participants reported that the program seemed logical ($M = 8.17$, $SD = 1.27$), that they expected CBCT to help them feel more connected to others ($M = 7.83$, $SD = 1.27$), and that they would be confident in recommending the program to a friend suffering from similar problems ($M = 8.25$, $SD = 1.06$). On a 1-7 scale, participants endorsed a high degree of internal motivation for treatment ($M = 6.67$, $SD = .57$) and confidence in CBCT ($M = 6.28$, $SD = .91$). Overall, participants denied having been pressured to get help ($M = 1.42$, $SD = .90$) and endorsed a moderate degree of help seeking motivation ($M = 5.25$, $SD = 1.40$).

With respect to engagement with the CBCT meditation practices, among participants who completed CBCT, 10 participants (100%) reported practice data. Participants engaged frequently in meditation practice, reporting, on average, 92.58 minutes of meditation per week ($SD = 44.62$), and 7.91 occasions of meditation practice per week ($SD = 2.56$). At the end of the intervention, participants reported a high degree of satisfaction with the program on the CSQ-8, $M = 28.89$, $SD = 3.33$. Participants' initial score on help seeking motivation was positively associated with their satisfaction (CSQ-8 score) at the end of the intervention, Spearman's Rho $r(7) = .84$, $p = .005$.

Hypothesis 4a: Exploring Pre-Post Change Following CBCT

Nine out of 10 CBCT participants completed the post-assessment[7]. Participants' SCS scores were not significantly higher at Assessment 2 ($M = 2.94$, $SD = .89$) than Assessment 1 ($M = 2.83$, $SD = .78$), $t(7) = -.74$, $p = .49$, $d = .13$, nor were CLCOS scores significantly higher at Assessment 2 ($M = 5.84$, $SD = 1.10$) than Assessment 1 ($M = 5.69$, $SD = 1.26$), $t(7) = -.71$, p

[7] One participant had unexpected triple bypass surgery after the 8th class and was unable to complete Assessment 2 due to his recovery. A second participant did not complete full measures at Assessment 1, and is thus missing from several pre-post analyses.

= .50, *d* = .13. Similarly, CLOHS scores were not significantly higher at Assessment 2 (*M* = 4.71, *SD* = 1.37) than Assessment 1 (*M* = 4.89, *SD* = 1.64), *t*(7) = 1.01, *p* = .35, *d* = .12. Results that will be presented in the parent study (Mascaro, in preparation) indicated that PTSD symptoms as measured by the PCL were significantly decreased at Assessment 2 (*M* = 53.68, *SD* = 14.70) compared to Assessment 1 (*M* = 63.44, *SD* = 11.43), *t*(8) = 3.50, *p* = .008, *d* = .74). Similarly, emotional numbing as measured by the General Numbing subscale was significantly decreased at Assessment 2 (*M* = 2.29, *SD* = .59) compared to Assessment 1 (*M* = 2.90, *SD* = .45), *t*(8) = 3.44, *p* = .009, *d* = 1.16. There were no significant differences between the Positive Numbing, Sad Numbing, Fear Numbing, or Anger Numbing subscale scores from Assessment 1 to Assessment 2 (*d's* ranged from .32 to .03). Change on the SCS was significantly associated with change on the PCL, *r*(6) = -.82, *p* = .01, such that veterans who reported greater increases in self-compassion reported greater decreases in PTSD symptoms; however, change on the SCS scores was not associated with change on General Numbing subscale, *r*(6) = -.5, *p* = .20. Change on CLCOS and CLOHS scores were not significantly associated with change on the PCL or General Numbing subscale (*r'*s ranged from .06 to .54, *p'*s ranged from .88 to .17).

There were no significant associations between the engagement variables (i.e., total minutes of practice, total occasions of practice, class attendance) and change on the SCS, CLCOS, PCL, or emotional numbing scores. The relationship between class attendance and change in the CLOHS was in the positive direction, but did not reach conventional levels of significance, *r*(6) = .70, *p* = .051, which likely is related to the small *n*. To address potential expectation bias, bivariate correlations were then computed between the PTSD symptom change scores (i.e., emotional numbing subscales and PCL) and the credibility, motivation and satisfaction ratings. No significant associations were found (*p* values ranged from .16 to .97;

Table 7).

Six veterans reporting having romantic partners and of these, five partners completed the questionnaires about relationship quality (i.e., RDAS and STLS Intimacy Scale). At Assessment 1, veterans reported a relatively high degree of intimacy on the Intimacy Scale, $M = 7.08$, $SD = 1.24$, and partners endorsed a similar degree of intimacy, $M = 6.93$, $SD = 1.89$. However, on the RDAS, veterans endorsed relationship distress, as all but one person's score fell at or below the RDAS cut-off score of 47, $M = 43.33$, $SD = 5.65$. Partners endorsed a similar degree of relationship distress on the RDAS, with greater variability, $M = 42.00$, $SD = 11.32$. Given the small number of couples who completed relationship measures, correlations and pre-post comparisons on these measures were not tested. At Assessment 2, only five veterans and three partners completed relationship measures; veterans again reported a relatively high degree of intimacy on the Intimacy Scale, $M = 7.54$, $SD = 1.54$, and partners again endorsed relatively high intimacy, $M = 7.44$, $SD = 1.36$. On the RDAS at Assessment 2, three veterans scores fell above the RDAS cut-off score of 47 and 3 fell below the cut-off score, $M = 47.83$, $SD = 7.28$. Partners again endorsed a similar degree of relationship distress on the RDAS, $M = 45.00$, $SD = 11.27$, with greater variability than veterans.

Discussion

In order to better understand and alleviate emotional numbing symptoms in individuals with PTSD, we examined psychophysiological, emotional, and social/relational correlates of numbing, and conducted a pilot trial of a novel intervention (CBCT) in a sample of male veterans with a trauma history. Our findings indicated that in this sample, self-reported emotional numbing was associated with higher self-reports of attachment insecurity, relationship distress, and lower compassion for self and others, as expected. However, self-reported emotional numbing was associated with higher heart rate variability and lower heart rate, which was contrary to hypotheses based on prior literature suggesting that higher heart rate is characteristic of PTSD samples. Furthermore, neither emotional numbing nor psychophysiological arousal (i.e., HRV and HR) were consistently associated with self-report ratings of arousal in response to emotionally evocative pictures. Thus, additional research is needed to further elucidate the relationships between emotional numbing, self-reported arousal, and cardiac functioning. Together, these findings suggest a disconnect between perceived and physiological arousal in this sample, and support the hypothesis that long-term numbing may be characterized by decreased sympathetic tone.

Results support the acceptability and credibility of CBCT as an intervention for male veterans with trauma histories, with participants reporting a high degree of engagement and satisfaction with the intervention. Furthermore, our preliminary findings suggest potential clinical benefit of CBCT, as significant decreases in emotional numbing and PTSD symptoms were reported following the intervention. However, the mechanism responsible for those changes remains unclear, as self-ratings of compassion for self or others did not significantly increase, as was expected, and the sample size was too small to conduct mediation analyses. Since there was no control condition, it may be simply that engagement in a credible intervention was sufficient to lead to some symptom improvement. Overall, this study highlights the importance of two lines of future research: 1) further elucidation of the relationship between self-reported emotional numbing and psychophysiological functioning in the context of PTSD, and 2) investigation of CBCT's efficacy and mechanisms in a randomized controlled trial.

Our first aim was to explore the associations between the most frequently used measurement approach to emotional numbing (i.e., a composite score based on ratings of the three Cluster C numbing symptoms) and a newer, continuous measure of emotional numbing (i.e., the ERNS). Based on our findings, we have reason to believe that the ERNS captures additional information about emotional functioning in PTSD above and beyond the traditional composite that has been widely used. As would be expected, the Cluster C composite score was most strongly associated with the ERNS General Numbing subscale ($r(45) = .59$) followed by the Positive Numbing subscale ($r(45) = .30$). The Fear, Anger, and Sad Numbing subscales were not correlated with the composite. Yet, the General Numbing, Positive Numbing, and Sad Numbing subscales were all consistently associated with both the psychophysiological and social/relational measures we examined, suggesting that numbing to particular types of emotional experiences is distinct from the traditional conceptualization of numbing and contributes to our understanding of the phenomenon. Specifically, like general numbing, numbing to positive emotions was associated with cardiac measures, attachment insecurity, self-compassion, and compassion for close others, with medium to strong effect sizes. Numbing to sadness had distinctly different patterns of association, showing associations with compassion for others but not self-compassion, attachment avoidance but not attachment anxiety, and no associations with cardiac measures. Unlike the other numbing variables, numbing to fear was unrelated to cardiac measures, compassion measures, and attachment avoidance. However, numbing to fear was strongly negatively associated with attachment anxiety and positively associated with self-compassion, indicating relationships with these variables in the opposite direction from the other numbing subscales.

Thus, while general numbing and numbing to positive emotions showed similar patterns of associations with psychophysiological and relational correlates, numbing to discrete negative emotions showed distinct patterns of associations with these correlates. Furthermore, among the

ERNS subscales, there was a trend for a negative association between numbing to positive emotions and numbing to fear (*r* = -.28), which would again be associated in the opposite direction from the other negative emotions (sadness and anger), both of which were strongly positively associated with numbing to positive emotions. Taken together, these results provide only partial support for Litz's (1992) model, which posited differential responding to positive and negative emotions in PSTD. Additionally, these results highlight the inadequacy of using the Cluster C numbing composite, given the nuanced relationships we found between the ERNS numbing subscales and physiological and relational correlates.

The second aim was to investigate whether and to what extent emotional numbing was associated with psychophysiological functioning, self-reported arousal, and relational functioning. Contrary to our predictions, emotional numbing scores were positively associated with HRV and negatively associated with HR, which were measured in the laboratory during a resting baseline and subsequent emotional stimuli conditions (i.e., IAPS photographs of differing valence and intensity). These findings seem to suggest concordance between the self-reported experience of emotional numbing and a lack of psychophysiological arousal, as individuals who reported more emotional numbing showed less sympathetic activity both during resting baseline and in response to the emotional stimuli. In keeping with these findings, the subset of participants who currently met DSM-IV symptom criteria for PTSD had significantly lower HR and higher HRV across the resting baseline and emotional stimuli conditions than those who did not. These findings were not consistent with previous literature indicating hyperreactivity to negative emotions and hyporesponsivity to positive emotions.

Instead, our results suggest that physiological blunting may be characteristic of emotional numbing in certain populations. Although these results are in contrast with several studies reporting higher resting HR in PTSD samples overall (see Pole, 2007), there is compelling evidence suggesting that physiological blunting may be more characteristic of populations with multiple (rather than single) traumas (e.g., McTeague et al., 2010) and PTSD patients with high levels of peritraumatic dissociation (Griffin, Resick, & Mechanic, 1997; Pole et al., 2005). McTeague et al. (2010) examined physiological reactivity during aversive imagery in healthy controls, patients who had experienced a single lifetime trauma, and patients with multiple lifetime traumas, for whom PTSD symptoms had persisted chronically (i.e., 17 years on average, compared to 5 years for the single-trauma group). Compared to single-trauma patients, those with multiple-traumas showed blunted physiological reactivity (i.e., fear potentiated startle and skin conductance) despite having the highest self-reported arousal of any group. Furthermore, single-trauma patients had significantly greater heart rate acceleration than controls during personal threat imagery, but the multiple-trauma group's acceleration was not significantly higher than controls. Interestingly, when initially comparing all PTSD patients as a whole to controls, the total PTSD group showed the expected pattern of higher physiological reactivity; however, this effect was driven by less than half of the total cohort (i.e., the single-trauma patients). These authors concluded that in populations with multiple traumas, chronic stress and persistent negative affect may accumulate over time, resulting in more chronic suppression of physiological responding. In the present study, our sample was characterized by multiple lifetime traumas (M = 5.64, SD = 2.44); all but two of the sample reported experiencing at least two lifetime traumatic events. Given that the physiological blunting phenomenon has also been found in some studies with PTSD populations (Blechert et al., 2007; Cohen et al., 2000; Cuthbert et al., 2003; Griffin et al., 1997) but not others (e.g., Norte et al., 2013), it may be necessary for future studies to account for heterogeneity of experiences within PTSD samples (e.g., trauma severity, frequency, and chronicity; trauma type; degree of dissociation during trauma).

Dissociation both during and after the traumatic event(s) may also explain these findings of physiological blunting in some patients with PTSD. Some studies have found that peritraumatic dissociation is associated with suppression of autonomic physiological responses, as well as showing discrepancy, with heightened self-reported distress but dampened physiological arousal (Griffin et al., 1997; Pole et al., 2005). For example, in a sample of female rape victims, Griffin et al. (1997) found that participants with high levels of dissociation during the trauma displayed significantly lower heart rate while talking about the rape and during a 5-minute resting recovery than low-dissociation participants. Thus, it is possible that for some individuals, dissociation is a mechanism used to deal with extreme fear at the time of trauma that ends up developing over time into a generalized coping strategy, resulting in suppressed or blunted physiological reactivity. It is also interesting that in Griffin's (1997) sample, the biggest difference in PTSD symptoms between the high-dissociation and the low-dissociation groups was in Cluster C avoidance/numbing symptoms, and that dissociation scores and avoidance/numbing symptoms were positively associated (r = .40). Marmar et al. (1994) reported a similar relationship between avoidance/numbing symptoms and retrospectively reported peritraumatic dissociation in Vietnam veterans, and found that when entered as the last step in logistic regression models, dissociation during trauma explained a significant portion of the variance in PTSD diagnosis over and above level of war zone stress exposure and general dissociative traits. Thus, taken together with research showing physiological blunting in some PTSD samples, our findings demonstrating suppressed sympathetic cardiac activity in veterans with more emotional numbing may be indicative of a subtype of PTSD characterized by autonomic blunting. In the case of a chronic, multiple-trauma sample like that in the present study, higher HRV and parasympathetic tone may actually be reflective of a shutting down or blunting effect. Both peritraumatic dissociation and lifetime trauma recurrence will be important variables to account for in future research aiming to characterize the relationship between emotional numbing and psychophysiological functioning.

Another possible explanation for our psychophysiological findings is the potential effect of medications on cardiac functioning, as in the case of benzodiazepines or anti-hypertensive drugs. Although use of these medications was included as a covariate in our analyses, it is likely that our sample was too small to detect any significant differences in cardiac variables based on medication use. In a much larger sample of active-duty marines (N = 2,430), Minassian et al. (2014) also did not find a significant association between psychotropic medication use and HF-HRV. Furthermore, Pole's (2007) meta-analysis found that aggregate psychophysiological effect sizes were not moderated by the exclusion of psychoactive medications across a number of different study types (e.g., trauma-cue studies; resting baseline). However, neither of these studies examined use of benzodiazepines or anti-hypertensive medications specifically.

To our knowledge, only one published study has examined the relationship between cardiac variables and emotional numbing in a PTSD sample (Flack et al., 2000). In a sample of roughly 800 Vietnam Veterans, heart rate reactivity to trauma-cues was positively associated with an emotional numbing composite score ($r = .20$), but when accounting for other variables, psychophysiological measures failed to predict emotional numbing scores in multiple regression models. However, their sample was limited to Vietnam veterans only, and reactivity was defined by HR response to combat-specific stimuli (i.e., sounds and images from the Vietnam war). It may be that the emotional stimuli presented in the current study (which were not combat related) were not of sufficient personal relevance or intensity to elicit a physiological response from the veterans that differed from resting baseline, which would be in line with some evidence suggesting that physiological hyperresponsivity in PTSD is limited to trauma-related stimuli (Casada, Amdur, Larsen, & Liberzon, 1998). It is also possible that a lack of physiological reactivity was due to the fact that veterans had completed the empathic accuracy task before seeing the emotional images, and had already become habituated to stimuli presented in the lab. However, the empathic accuracy videos were of lesser intensity and valence than the IAPS images and were also unrelated to combat, such that habituation to intensely valenced stimuli would not be expected. This interpretation is supported by the fact that we found no differences in HR or HRV across the different categories of emotional stimuli, despite significant differences in self-reported arousal across these image conditions.

Furthermore, self-reported arousal was not associated with physiological arousal in any image condition, except during Hi Neg images, suggesting concordance between self-reported arousal and sympathetic arousal in the overall sample only when viewing high intensity negative stimuli. This general pattern of results may be understood in the context of literature showing discordance between self-reported arousal and psychophysiological arousal in PTSD samples (Wessa, Karl, & Flor, 2005). For example, in a sample of combat veterans with and without PTSD, Amdur et al. (2000) found no significant correlation between subjective ratings of emotional responses and psychophysiological indicators of response, including heart rate, facial EMG, and skin conductance response. Other researchers have found discordance between autonomic reactivity and behavioral responses in lab tasks, such that despite showing expected behavioral change on a motivated behavior task, PTSD patients did not show the expected changes in heart rate and skin conductance, as did controls (Casada & Roache, 2006). This discordance in physiology and behavior may in fact be a facet of emotional numbing, such that suppressed physiology may serve as a protective or dissociative response to stressful stimuli. Similarly, we found that self-reported arousal ratings were not associated with self-reported emotional numbing scores overall. It could be that because a self-report instrument like the ERNS measures emotional numbing at the global, trait-like level, there may be little concordance with temporary state indices of subjective emotional arousal measured in a laboratory setting. However, given the associations found between this measure of numbing and the state psychophysiological variables in the lab, it may be that suppressed physiology is an important component of emotional numbing, perhaps reflecting a "shutting down" effect. To address this question, it would have been necessary to compare not only the self-reported arousal but also the physiological arousal of healthy controls to individuals with PTSD, as the self-report/physiological discrepancy is reported frequently in the literature (e.g., Kring, 1998).

With respect to the social functioning of veterans in our sample, we found evidence that higher emotional numbing was associated with poorer relational functioning across multiple measures. Consistent with previous literature (e.g., Besser et al., 2009), we found that emotional numbing was positively associated with attachment insecurity, suggesting that individuals with more emotional numbing are more likely to endorse tendencies consistent with an insecure attachment style. For those veterans who reported being in a current relationship, relationship quality with romantic partners as measured by the RDAS was negatively associated with general emotional numbing. Although few partners of veterans participated in the study, overall baseline reports from CBCT participants and their partners indicated a moderate degree of relationship distress. These findings are supported by the broader literature on social and romantic relationship dysfunction in PTSD (e.g., Riggs et al., 1998). To our knowledge, this is the first study to assess compassion for self and others and test associations with emotional numbing, finding that compassion was negatively associated with emotional numbing. It may be that individuals with higher emotional numbing symptoms are more likely to struggle with feeling compassion for themselves and others (both close and distant) as a result of blunting of positive emotions, social withdrawal and subsequent loss of social support, or other negative cognitions altered by the traumatic event (e.g., distorted blame of self or others for the event or its consequences).

The third aim of the study was to pilot and evaluate the feasibility of CBCT in a sample of veterans with a history of PTSD due to military trauma who were willing to participate in the intervention (n = 10). At baseline, these male veterans (ranging in age from 31 to 69) reported that CBCT was a credible intervention and reported high motivation to participate. Over the 10-week course, they reported a high level of engagement with the meditation practices, spending an average of over 90 total minutes in meditation practice per week and meditating nearly eight times per week. Overall, the veterans reported a high degree of satisfaction with the intervention, which was positively associated with their initial degree of motivation to seek help. Retention rates were high, with 83% of veterans completing CBCT. In our sample, veterans' level of engagement and satisfaction with the CBCT class were comparable to those reported in Bormann et al.'s (2013) study of mantram meditation for veterans with chronic PTSD. Taken together, both Bormann et al. (2013) and our findings are particularly positive considering that these veterans had already received a variety of treatments and most had in fact already benefited from those in terms of their more acute symptoms. The fact that these veterans remained open to engaging in alternative, less traditional interventions supports the conclusion that residual symptoms of emotional numbing are experienced as sufficiently distressing to motivate some veterans to seek additional treatment. While it was not clear that increased compassion was a significant mechanism of change (or will be in future studies), it is worth noting that a rationale to increase compassion was considered appropriate and reasonable by this small group of veterans. Ten weeks is a relatively short time to address longstanding symptoms so longer or more intensive intervention may also need more consideration.

Our final aim was to determine whether participation in CBCT was associated with any changes in emotional numbing, PTSD symptoms, or relational functioning. Analyses revealed theory and hypothesis-consistent outcomes with respect to decreases in emotional numbing (d = 1.16) and PTSD symptoms (d = .74) following CBCT. These findings are consistent with results from Tan et al. (2011) who also found significant reductions in PTSD symptoms following a biofeedback intervention (d = .1.08) and Bormann et al. (2013), who found significant reductions in both PCL scores (d = .51) and Cluster C avoidance/numbing symptoms (d = .57) following a mantram meditation intervention. In contrast, self-reported compassion for self-and others was not significantly increased following CBCT. However, post hoc power analyses for the compassion measures indicated that given the small effect sizes (d = .13; d = .12) and sample size of 8 veterans, we were significantly underpowered (power estimates ranged from .09 to .14); an n of approximately 125 would be needed to obtain statistical power at the recommended .80 level. While we did not find any significant associations between frequency of at-home meditation practice and the outcomes we tested, this may have been both an issue of sample size and restricted range in the practice variables, as most of the veterans engaged frequently in the practices. We were even more underpowered to test pre-post changes in relationship quality given the small number of CBCT participants who were in a relationship (n = 6) and the smaller number of couples who completed relationship measures at both time points (n = 3).

Strengths and Limitations

This was the first study to examine associations between a continuous measure of emotional numbing (i.e., the ERNS) versus the composite score based on the three DSM-IV numbing symptoms (that has typically been used in emotional numbing research) and physiological arousal, self-reported arousal, and relational measures. Although the link between self-reported hyperarousal symptoms and emotional numbing symptoms has been well established (e.g., Litz et al., 1997), the relationship of psychophysiological functioning to emotional numbing remains to be understood. Our results are the first to provide evidence for a moderate association between emotional numbing and cardiac functioning (i.e., HR and HRV), indicating that in some cases and/or contexts, chronic PTSD may be characterized by psychophysiological blunting rather than hyperreactivity. Lastly, this was the first study to pilot compassion meditation training with a diverse group of combat veterans who have a history of PTSD. Our findings suggest that compassion-based meditation approaches may be of significant interest and benefit to a male veterans with chronic PTSD who are motivated to seek help.

Several limitations to the present study should be noted. In our final sample (n = 47) there was an overrepresentation of veterans reporting significant levels of current PTSD symptoms (70% reporting a history of PTSD diagnosis and 55% still meeting full criteria). Because we did not have access to VA records, we were unable to verify self-reported PTSD symptoms/diagnosis with medical records. It is possible that overreporting or feigning of PTSD symptoms could explain the unexpected psychophysiological findings in our sample. On the NDS, only one participant scored above the *85T* cut-off recommended by Thomas et al. (2012) for use when aiming to correctly classify individuals with PTSD. However, if indeed there was a substantial degree of PTSD overreporting in our sample, as has been found in samples of compensation-seeking veterans (Frueh et al., 2003), the true associations between cardiac variables, emotional numbing, and PTSD status may have been obscured. It will be important in future analyses of these data to include NDS scores as a covariate in models testing associations with PTSD symptoms and outcomes. Nevertheless, with the exception of veterans allocated to the CBCT cohort, the baseline cohort was explicitly *not* required to have a PTSD diagnosis to participate. Further, the study was not conducted at, or in any affiliation with the Veterans Administration, which was made clear to participants and should have reduced motivation to overreport symptoms.

Second, we used a standard self-report measure of PTSD symptoms rather than a clinician rated interview, such as the CAPS, which may have inflated the number of participants meeting criteria for a PTSD diagnosis. Next, our three measures of compassion (i.e., SCS, CLCOS, CLOHS) are somewhat overlapping constructs. Although self-compassion was not associated with compassion for strangers or close others, the CLCOS and the CLOHS were strongly associated with one another (r = .58). Further, because our sample was restricted to male veterans, our findings cannot be generalized to female veterans. Aside from gender, however, our sample was notably diverse in age, ethnicity, and socioeconomic status. Third, due to the cross-sectional nature of this study's first aim, we are unable to test the potential for causal (or transactional) relationships between emotional numbing, cardiac measures, and measures of relational/social functioning. Prospective studies will be needed to identify predictors and sequelae of emotional numbing symptoms, specifically with respect to psychophysiological variables, such as HRV. Furthermore, because we did not have access to medical records, we were unable to confirm which medications and dosages participants were taking beyond self-report. Finally, without having a comparison group of healthy controls or having measured peritraumatic dissociation, we were unable to test the hypotheses that the physiological hyporeactivity found in our sample might be due to multiple-traumas or to dissociation.

With respect to the CBCT intervention, we cannot determine whether specific elements of this intervention were responsible for the significant decreases in emotional numbing and PTSD symptoms because we did not have a control group for comparison. It is impossible to rule out other potential mechanisms, such as spontaneous improvement with the passage of time. An alternative explanation is that sharing time and disclosing personal information with a group of fellow veterans could have been more important to symptom reduction than the content taught in CBCT. Further, given the small sample of veterans who participated in CBCT, we had limited power to test several hypotheses (i.e., relationship quality changes; pre-post analyses for compassion measures) or explore pre-post changes in physiological responses.

Despite the high levels of motivation, engagement, and satisfaction in our CBCT sample, 40% of veterans who initially expressed interest in the CBCT course failed to attend any classes. It is important to acknowledge that this rate of enrollment may reflect that there are significant barriers to participation in a meditation course for a large percentage of veterans. It may be that either the time commitment or content of CBCT was not appealing for some male veterans with PTSD. Two eligible participants specifically stated that competing time commitments would prohibit participation in the course. With respect to the content of CBCT, it may be that for a portion of eligible veterans, the prospect of targeting compassion for oneself and others was aversive. Recently, Gilbert and colleagues (2011) proposed that individuals with a range of psychopathologies may experience fear or aversion toward certain positive emotions, such as compassion, which may lead them to suppress these emotions and avoid experiences that might elicit them. Preliminary support for this theory was reported in a study that found higher fears of positive emotions in a depressed sample as compared to a college student sample (Gilbert et al., 2012), using the Fear of Compassion (both for self and from others) and Fear of Happiness scales (Gilbert, McEwan, Catarino, Baião, & Palmeira, 2014; Gilbert et al., 2011). In the depressed sample, fear of these positive emotions was significantly associated with alexithymia, depression, adult attachment, and stress, and fears of positive emotion fully mediated the relationship between alexithymia and depression (Gilbert et al., 2014). Comorbid depression or other mental illnesses may also be a barrier to engagement. In fact, one veteran who dropped out after allocation to CBCT called study staff nine weeks later to apologize for failing to attend and explained that he had been experiencing a depressive relapse.

Future Directions

As results of this study suggested that the ERNS may provide useful information over and above the traditional Cluster C numbing composite score, a further extension of this aim will be to compare the utility of these distinct numbing measures as predictors in regression models for correlates of interest. Next, given that we found suppressed cardiac reactivity in veterans with higher emotional numbing and PTSD symptoms, it will be interesting to examine the facial EMG data that was collected as part of the larger parent study and compare these two indices of psychophysiological reactivity. We also hope to examine veterans' valence ratings of the IAPS images as a covariate in future analyses with psychophysiological variables, as previous research has suggested that ratings of valence and arousal are negatively correlated in PTSD participants, but not for controls (Amdur et al., 2000). An examination of veterans' psychophysiological responses to the empathic accuracy task videos (i.e., real people telling stories of negative and positive life events) may also be useful in interpreting these findings. Further, as mentioned above, it will be critical for future research on emotional numbing to take into account the variety of experiences within participants, including trauma type, severity, frequency, and chronicity, and the extent to which participants experienced peritraumatic dissociation. More prospective studies are needed to test the dissociation hypothesis as it potentially relates to blunted psychophysiology in individuals exposed to trauma, and future studies should test these questions in a larger sample, as only 44 out of 47 participants in the present study had analyzable cardiac data. It would also be useful in a future study to examine these questions in a non-veteran PTSD sample, in order to avoid the higher potential for symptom overreporting in veteran samples and compare military/combat trauma with other types of trauma histories.

The psychophysiology of PTSD has been conceptualized by some as a failure to recover and return to homeostasis after a stressor or a challenge (Yehuda & LeDoux, 2007). In fact, the findings in Pole's (2007) meta-analysis suggested that the most robust effect in PTSD was the failure to recover after being startled; in other words, disturbances in recovery (i.e., psychophysiological regulation) may be more important than the magnitude of the initial psychophysiological response. As Pole (2007) noted, future research in this area should distinguish sympathetic and parasympathetic influences on cardiac activity, as "the regulation of psychophysiological response in PTSD may be more important than the magnitude of response" (p. 742). Thus, an extension of the current study may do better to focus on HRV reactivity and recovery, perhaps following a more trauma-relevant stressor.

Lastly, given the initial success of piloting CBCT with male combat veterans and large effects for reductions in emotional numbing and PTSD symptoms, conducting a randomized controlled trial will be a critical next step. Given the high rates of veterans returning from combat with PTSD and/or having previous lifetime trauma (Wisco et al., 2014) and the significant percentage of cases that do not remit with currently available treatments (Zlotnick et al., 2004), it is critical to test alternative interventions to target residual symptoms that persist chronically. A future study testing CBCT in this population would ideally be established within a Veterans Administration system, so as to have access to a greater number of potentially interested participants.

Conclusions

In this study, we incorporated psychophysiological measures, subjective arousal reports, and social/relational measures in order to begin to understand how these domains of functioning relate to self-reported symptoms of emotional numbing. Our initial investigation suggests that emotional numbing is associated with attachment insecurity, poor relationship health, and decreased compassion for self and others. Results called into question the notion that higher psychophysiological arousal characterizes PTSD samples, as both emotional numbing and PTSD status were associated with lower HR and higher HF-HRV in this sample of veterans with a trauma history. Overall, our findings did not support a pattern of hyperreactivity to negative emotions coupled with hyporeactivity to positive emotions, and instead suggest the importance of taking into account heterogeneity within trauma-exposed samples. Further analyses of these data in conjunction with additional data from the parent study may help to elucidate the relationships between emotional numbing and these correlates.

Lastly, we piloted a group-format compassion meditation intervention (i.e., CBCT) in a sample of male veterans with a history of PTSD due to military trauma, and found that veterans perceived the intervention as credible, were highly engaged, and reported promising improvements on emotional numbing and PTSD symptom measures. These results suggest that CBCT may be a useful alternative/complimentary intervention for veterans suffering from chronic PTSD symptoms and emotional numbing, and warrant testing CBCT in a randomized controlled trial and exploring possible mechanisms of action. Overall, results from this study highlight the importance of more precisely characterizing how emotional numbing works in the context of PTSD in order to more directly and effectively target intervention efforts.

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Appendix A: Tables

Table 1

CBCT Protocol

1. **Developing Attention and Stability of Mind:** The foundation for the practice is the cultivation of a basic degree of refined attention and mental stability.

2. **Cultivating Insight into the Nature of Mental Experience:** The stabilized mind is then employed to gain insight into the nature of the inner world of thoughts, feelings, emotions and reactions.

3. **Cultivating Self-Compassion:** The student participant observes the innate aspirations for happiness and wellbeing as well as those for freedom from unhappiness and dissatisfactions, i.e., which mental states contribute to fulfillment and which ones prevent it. The participant then makes a determination to emerge from the toxic mental and emotional states that promote unhappiness.

4. **Developing Equanimity and Impartiality:** Normally one tends to hold fast to categories of friends, enemies, and strangers and to react unevenly to people, based on those categories, with over-attachment, indifference and dislike. By examining these categories closely, the participant comes to understand their superficiality and learns to relate to people from a deeper perspective: everyone is alike in wanting to be happy and to avoid unhappiness.

5. **Developing Appreciation, Affection, and Empathy for Others:** Although people view themselves as independent, self-sufficient actors, the truth is that no one can thrive or even survive without the support of countless others. When the participant realizes interdependence with others and the many benefits which others offer every day, the participant develops appreciation and gratitude for them. Developing affection and empathy then follows, and involves a two-pronged approach: reflecting on the kindness of others and reflecting on the many drawbacks of a self-centered attitude. The latter weakens out self-centeredness, while the former is the active component that strengthens endearment and affection towards others. That endearment and enhanced empathy serves as the catalyst for compassion. The more endearment we feel towards another, the more unbearable we will find their suffering and difficulties, and the more we will rejoice in their happiness and good fortune. (cite Singer paper) We will then be impelled to see them relieved of their distress, which is compassion. Deeper contemplation and insight into the ways in which myriad benefits are derived from countless others, along with awareness that this kindness should by rights be repaid, enables the participant to relate to others with a deeper sense of connectedness and affection. By relating to others with a profound sense of affection and endearment, the participant is able to empathize deeply with them. The participant cannot then bear to see others suffer any misfortune and rejoices in their happiness.

6. **Realizing Engaged Compassion:** Enhanced empathy for others, coupled with intimate awareness of their suffering and its causes, naturally gives rise to compassion: the wish for others to be free from suffering and its conditions. For engaged compassion, the participant is guided through a meditation designed to move from simply wishing others to be free of unhappiness to actively committing to assistance in their pursuit of happiness and freedom from suffering. Consistent meditation training develops a greater capacity for compassion, which eventually will become ingrained and spontaneous.

Table 2

Participant Baseline Characteristics

Participant Characteristic	CBCT Group Only (*N* = 10)	Baseline Assessment Only (*N* = 37)
Age: *M* (*SD*)	52.00 (14.24)	47.70 (14.20)
Relationship status: *n* (%)		
Married or cohabitating	5 (50.00)	11 (29.73)
Not in a relationship	5 (50.00)	19 (51.35)
In a relationship but not living together	0 (0.00)	7 (18.92)
Education: *n* (%)		
College or advanced degree	6 (60.00)	6 (16.22)
Some college or technical school	4 (40.00)	25 (67.57)
Graduated from high school or equivalent	0 (0.00)	6 (16.22)
Ethnicity/Race: *n* (%)		
Black or African American	3 (30.00)	20 (54.05)
White	4 (40.00)	10 (27.03)
Other	3 (30.00)	7 (18.92)
Household yearly income: *n* (%)		
≤ $10,000	2 (20.00)	11 (29.73)
$10,000 - $49,999	3 (30.00)	17 (45.95)
$50,000 - $99,999	5 (50.00)	5 (13.51)
$100,000 - $150,000	0 (0.00)	3 (8.11)
Employment Status: *n* (%)		
Unemployed and/or on disability	4 (40.00)	13 (35.14)

Retired	5 (50.00)	9 (24.32)
Employed (full or part-time)	1 (10.00)	14 (37.84)
Military Service: *n* (%)		
Enlisted	10 (100.00)	34 (91.89)
Drafted	0 (0.00)	3 (8.11)
Combat Era: *n* (%)		
Vietnam era *age range: 63-72*	4 (40.00)	7 (18.92)
Post-Vietnam *age range: 35-59*	2 (20.00)	14 (37.84)
2001 and after (OEF/OIF) *age range: 25-49*	4 (40.00)	16 (43.24)
Trauma Exposure		
Combat Zone	9 (90.00)	32 (86.49)
Sexual Assault	3 (30.00)	7 (18.92)
Non-sexual Assault	7 (70.00)	21 (56.76)
Total # Lifetime Traumatic events: *M* (*SD*)	5.40 (2.37)	5.70 (2.49)
PTSD Checklist (PCL) Score: *n (%)*	63.20 (10.80)	52.08 (17.80)
Meets Full DSM-IV PTSD criteria: *n (%)*	8 (80.00)	25 (67.57)
EN Composite: *M* (*SD*)	3.60 (1.09)	3.07 (1.24)
ERNS General Numbing Score: *M* (*SD*)	3.07 (.68)	2.49 (.85)

OEF = Operation Enduring Freedom, *OIF* = Operation Iraqi Freedom, *EN Composite* = Average of 3 DSM-IV Cluster C numbing symptoms: items 9, 10, 11 on the PCL, *ERNS* = Emotional Reactivity and Numbing Scale. Note that the General Numbing subscale does not reflect a total ERNS score, but rather general numbing to the full range of emotional experiences.

Table 3

Correlations among ERNS Subscale Scores and Cluster C Numbing Composite Score (n = 47)

ERNS Subscale	General Numbing	Positive Numbing	Sad Numbing	Fear Numbing	Anger Numbing
General Numbing	-				
Positive Numbing	.54**	-			
Sad Numbing	.47**	.46**	-		
Fear Numbing	-.17	-.28†	.33*	-	
Anger Numbing	.06	.40**	.45**	.33*	-
C Composite	.59***	.30*	.05	-.22	-.10

†$p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$. *ERNS* = Emotional Reactivity and Numbing Scale.

Note. Higher ERNS subscale scores indicate greater emotional numbing. *C Composite* = Average of 3 DSM-IV Cluster C numbing symptoms: items 9, 10, 11 on the PCL.

Table 4

Correlations among Numbing Subscale Scores and Cardiac Variables (n = 44)

ERNS Subscale:	General Numbing	Positive Numbing	Sad Numbing	Fear Numbing	Anger Numbing
HF-HRV	.39**	.46**	.31*	.07	.18
Heart Rate	-.33*	-.46**	-.16	.06	-.11

†$p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$, *ERNS* = Emotional Reactivity and Numbing Scale. High Frequency Heart Rate Variability (ms^2/Hz, log transformed). *Note*. Higher subscale scores indicate greater emotional numbing.

Table 5

Correlations among Numbing Subscale Scores and Attachment Insecurity (n = 47)

ERNS Subscale:	General Numbing	Positive Numbing	Sad Numbing	Fear Numbing	Anger Numbing
ECR-R Anxiety	.42**	.38**	.06	-.48**	-.12
ECR-R Avoidance	.47***	.44**	.36*	.06	.17
RDAS	-.50**	-.31†	-.09	.22	-.07

†$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$, *ERNS* = Emotional Reactivity and Numbing Scale. *ECR-R* = Experiences in Close Relationships-Revised Questionnaire. *RDAS* = Revised Dyadic Adjustment Scale. *Note*. n = 30 for correlations with the RDAS, as only a portion of participants were in a current relationship. Higher subscale scores indicate greater emotional numbing.

Table 6

Correlations among Numbing Subscale Scores and Compassion Variables (n = 47)

ERNS Subscale:	General Numbing	Positive Numbing	Sad Numbing	Fear Numbing	Anger Numbing
SCS					
Self-Kindness	-.44**	-.50***	-.18	.28†	.03
Mindfulness	-.40**	-.55***	-.16	.31*	.06
Common Humanity	-.35*	-.31*	-.05	.24	.18
Isolation	.49**	.44**	.12	-.36*	-.06
Self-Judgment	.47**	.44**	.07	-.30*	.08
Over-Identified	.43**	.41**	.01	-.38**	-.18
Overall Self-Compassion	-.54***	-.56***	-.12	.39**	.08
CLCOS	-.45**	-.40**	-.60***	-.09	-.04
CLOHS	-.31*	-.29†	-.47**	-.30*	-.14

†$p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

ERNS Emotional Reactivity and Numbing Scale; *CLCOS* Compassionate Love for Close Others; *CLOHS* Compassionate Love for Humanity; *SCS* Self-Compassion Scale. *Note*. Higher subscale scores indicate greater emotional numbing.

Table 7

Correlations among PTSD symptom change and expectation variables (n's ranged from 8-9)

Change Score *(below)*	Internal Motivation	Confidence in CBCT	Help Seeking Motivation	Credibility	Satisfaction
General Numbing	.25	.03	.51	.13	.32
PCL	-.27	-.09	-.43	-.23	-.02

†$p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$, *PCL* = Posttraumatic Stress Disorder Symptom Checklist. General Numbing is a subscale of the Emotional Reactivity and Numbing Scale.

Appendix B: Figures

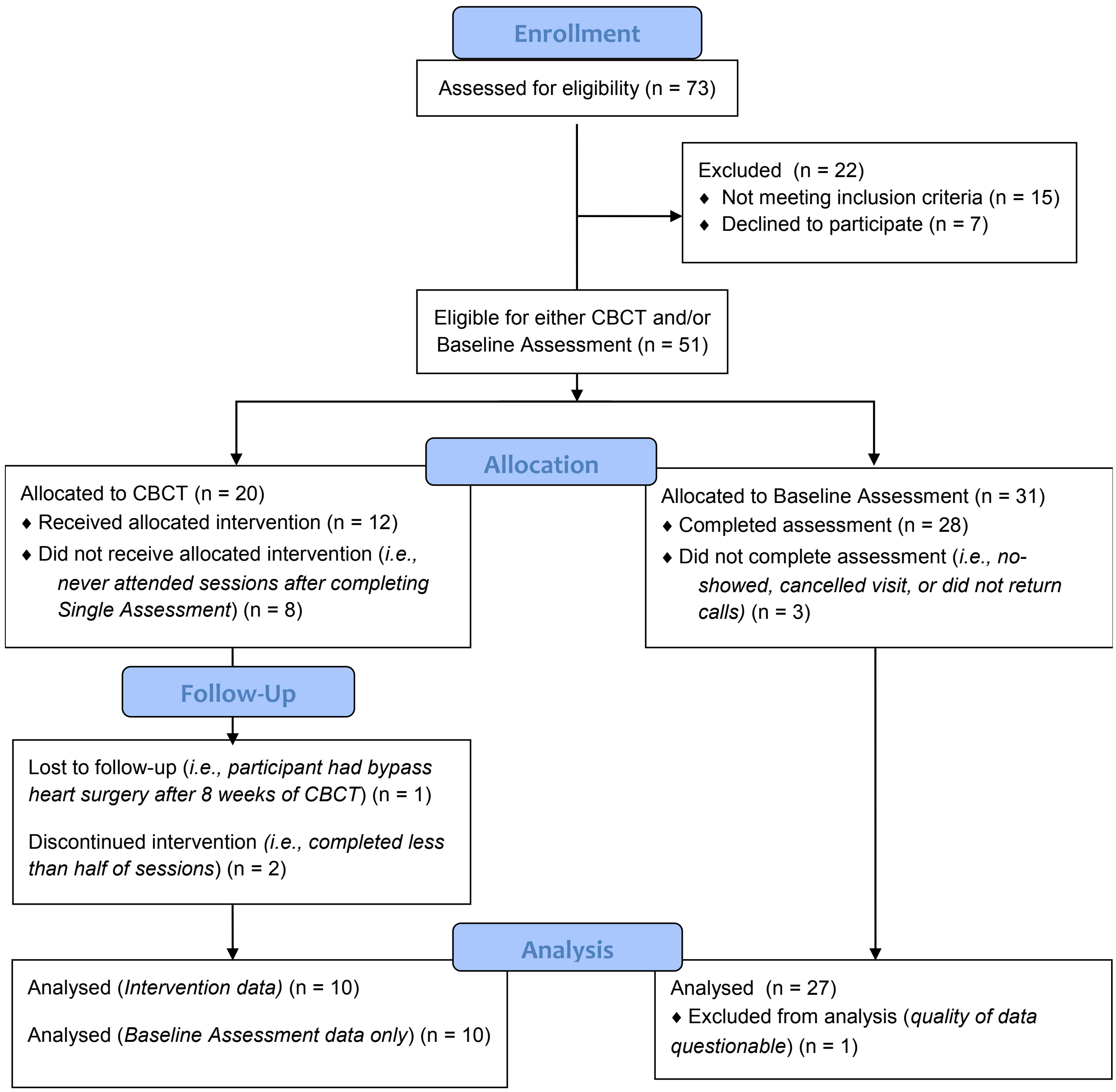

Figure 1. CONSORT Flow Diagram.

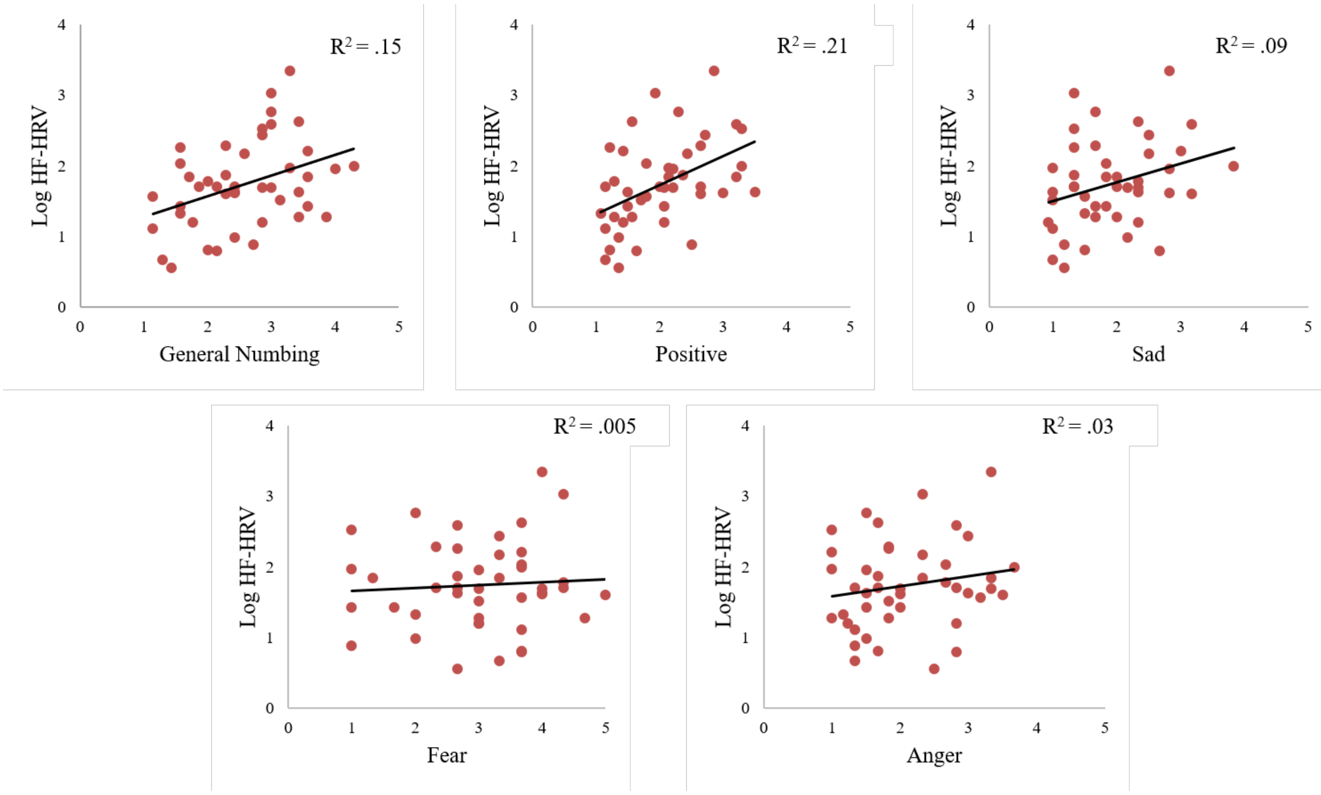

Figure 2. High Frequency HRV by Numbing Subscale Scores.

HF-HRV = High Frequency Heart Rate Variability (ms^2/Hz). *Note*. Higher subscale scores indicate greater emotional numbing.

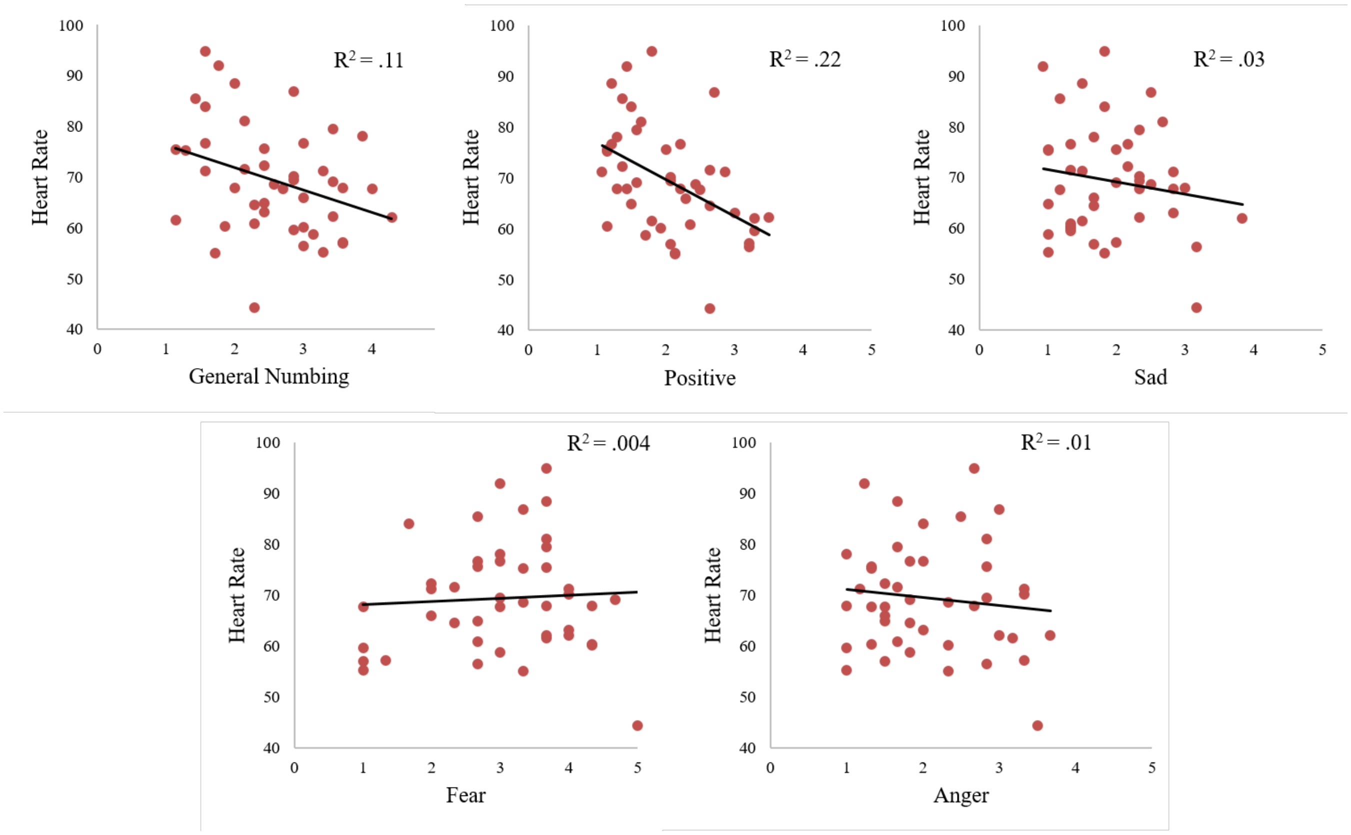

Figure 3. Heart Rate by Numbing Subscale Scores.

Note. Higher subscale scores indicate greater emotional numbing.

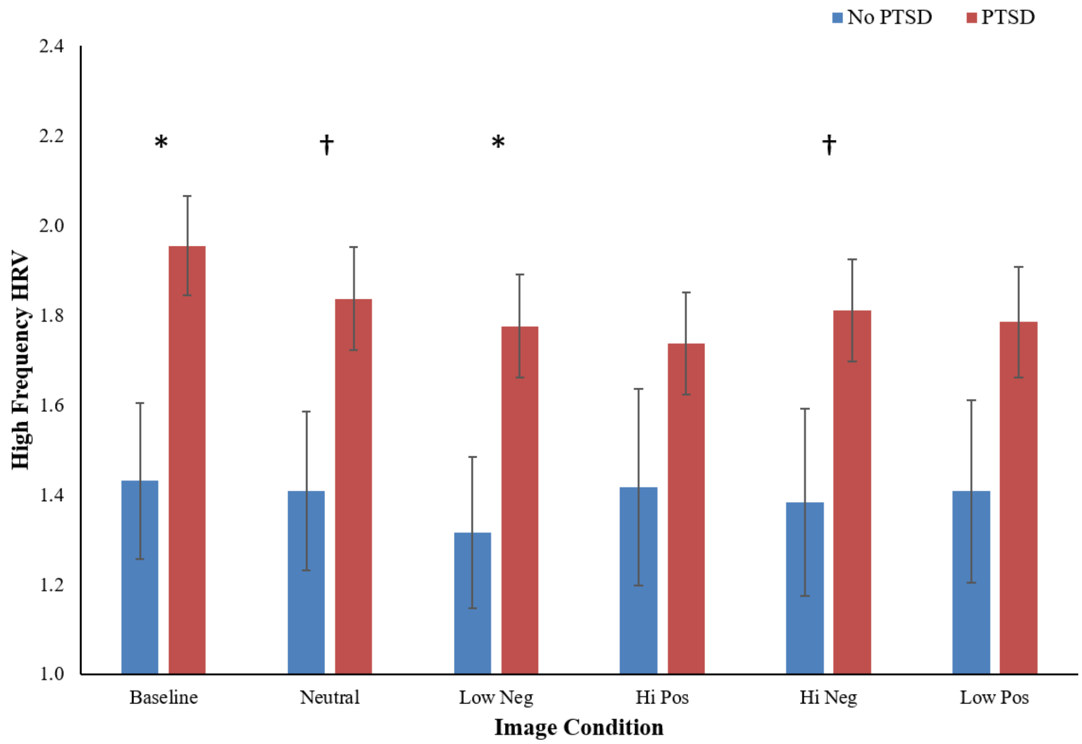

Figure 4. High-frequency HRV by image condition and diagnostic category. *High Frequency HRV* = High Frequency Heart Rate Variability (ms^2/Hz, log transformed), T-tests were conducted to identify significant differences between groups within each image condition, †$p < .10$, * $p < .05$. *Note*. Participants were not shown any images during the baseline condition.

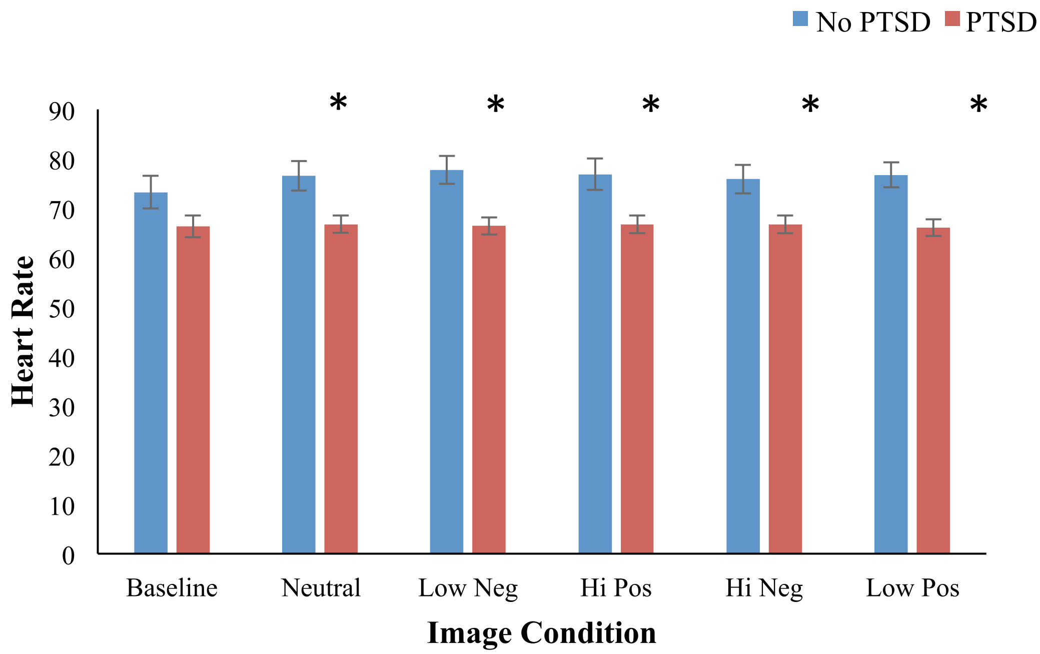

Figure 5. Heart rate by image condition and diagnostic category.

T-tests were conducted to identify significant differences between groups within each image condition. †$p < .10$, * $p < .05$

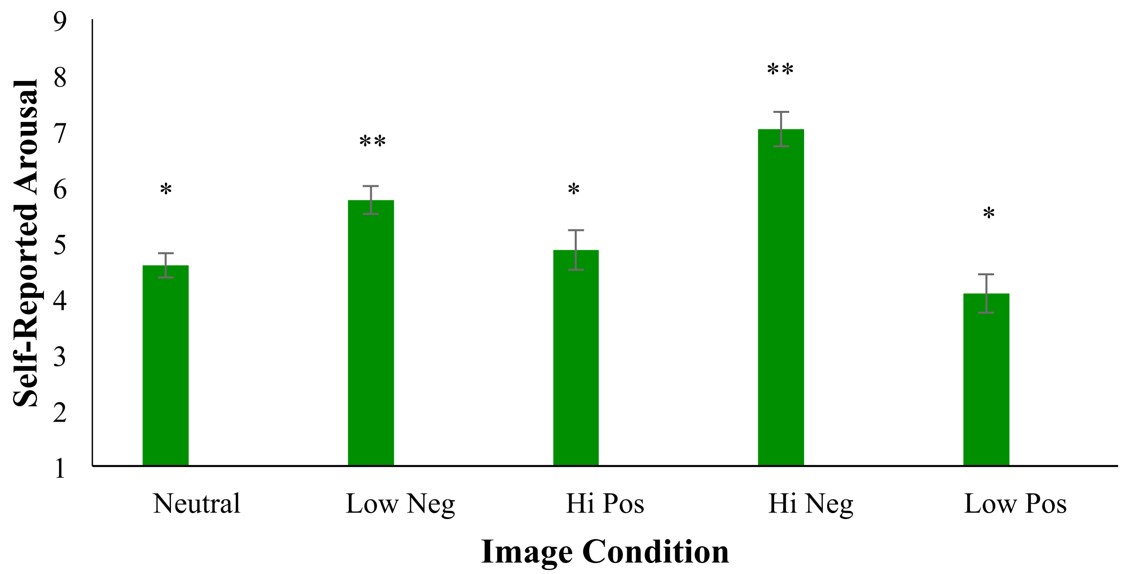

Figure 6. Self-reported arousal by image condition.

**Arousal level is significantly different from all other conditions at the .05 alpha level

*Arousal level is significantly different from all but one condition at the .05 alpha level