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Self-efficacy as a Mediator of Response to a Mindfulness Intervention for People with PTSD and Emotion Dysregulation

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An abstract of
a dissertation submitted to the Faculty of the
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Abstract

Self-efficacy as a Mediator of Response to a Mindfulness Intervention for People with PTSD and Emotion Dysregulation

By Andrew P. Teer, M.A.

Post-traumatic stress disorder (PTSD) is chronic, debilitating disorder characterized by avoidance and emotion dysregulation. A subgroup of individuals with PTSD experience high levels of emotion dysregulation. This population has been characterized by low levels of self-efficacy, or the belief that one is able to perform the necessary actions in order to obtain a desired outcome. A low level of self-efficacy is thought to play a role in the development and maintenance of posttraumatic stress disorder. Conversely, high levels of self-efficacy may buffer against the deleterious effects of trauma, possibly by decreasing the use of avoidance as a coping mechanism. One new potential avenue for treating PTSD is the use of mindfulness-based interventions that use attending to the present moment to help individuals manage emotional distress. Mindfulness-based interventions have been shown to improve self-efficacy, particularly in populations with emotional dysregulation, and have likewise been successful in treating symptoms of PTSD. However, self-efficacy has not yet been examined as a potential mechanism through which mindfulness practices may improve emotion dysregulation and ameliorate PTSD symptoms. In this study, self-efficacy will be examined as a mediator of response to a brief breath-focused mindfulness meditation intervention for traumatized people with variable levels of emotion dysregulation. Response to this intervention will be measured both by changes in self-reported PTSD and emotion dysregulation and changes in a psychophysiological index of autonomic response (heart rate variability, or HRV). Participants were 55 women recruited for a brief, computerized breath-focused mindfulness meditation (BFMM) intervention. Analyses of mediation and conditional indirect effects (i.e., moderated mediation) were performed using the PROCESS macro for SPSS (Hayes, 2013), and bootstrapped confidence intervals were utilized to facilitate statistical inference. Results demonstrated that the BFMM intervention did have its intended effects in reducing symptomatology and improving functioning, including increased coping self-efficacy. Changes in coping self-efficacy did not mediate the relationship between pre- and posttreatment 1) PTSD symptoms, 2) dissociative symptoms (as a proxy for emotion dysregulation), and 3) average HRV. Furthermore, average HRV did not correlate with any self-report measures tested. Lastly, moderated mediation analysis was conducted to examine whether or not the indirect effects of change in coping self-efficacy were conditionally affected by pretreatment emotion dysregulation, which was not supported by the data. Taken together, the findings point toward a more complex relationship between pretreatment emotion dysregulation and change in self-efficacy than what this study was designed to examine.

Key words: self-efficacy, emotion dysregulation, mindfulness, trauma, PTSD

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Background and Introduction

Post-traumatic Stress Disorder

Posttraumatic stress disorder (PTSD) is a chronic mental health disorder that can result from "actual or threatened death, serious injury, or sexual violence" through direct experience, witnessing the trauma in person, or learning that the trauma happened to a close loved one unexpectedly(American Psychological Association, 2013). According to the fifth edition of the Diagnostic and Statistical Manual (American Psychological Association, 2013), PTSD is marked by symptoms of recurrent, intrusive re-experiencing, persistent avoidance of internal and external trauma-related stimuli, negative alternations in cognition and mood associated with the trauma, and elevation in physiological arousal and reactivity. PTSD presents clinically in several different ways: "in some individuals, fear-based re-experiencing, emotional, and behavioral symptoms may predominate … [for] others, anhedonic or dysphoric mood states and negative cognitions may be most distressing … [in] other individuals, arousal and reactive-externalizing symptoms are prominent, while in others, dissociative symptoms predominate" (American Psychological Association, 2013). Traumatized individuals with severe affect dysregulation often have histories of chronic and early-onset trauma (Herman, 1992; Perry, Herman, van der Kolk, & Hoke, 1990); thus, for many of these individuals, these dysregulated responses are fairly entrenched and that much more difficult to treat. As such, treatment success for this group of traumatized individuals is generally poor and has been associated with high attrition rates. For example, one treatment study in a specialty CBT clinic found that patients with PTSD and borderline personality disorder (BPD) – a diagnosis characterized by marked affective instability – dropped out at twice the rate of those without the comorbid diagnosis (Zayfert, DeViva, Becker, Pike, & Gillock, 2005). Another treatment study for early intervention exposure therapy demonstrated that dissociation during the first treatment session attenuated treatment response (Price, Kearns, Houry, & Rothbaum, 2014). This finding supports other evidence of dissociation's negative impact on response to trauma therapy (Bae, Kim, & Park, 2016; Lanius, Brand, Vermetten, Frewen, & Spiegel, 2012).

A subgroup of patients with posttraumatic stress disorder (PTSD) experience high levels of emotion dysregulation (e.g. Cloitre, Courtois, et al., 2012). This emotion dysregulation can manifest in several ways, including emotional avoidance (Gratz, Rosenthal, Tull, Lejuez, & Gunderson, 2006), impulsive behavioral responses to emotions (Weiss, Tull, Viana, Anestis, & Gratz, 2012), extreme emotional lability, attentional disruption and aggression (Shields & Cicchetti, 1998). One of the most common manifestations of emotion dysregulation is emotional avoidance, which Hayes and Gifford (1997) have defined as the tendency to try to avoid unwanted emotions by suppressing them. Paradoxically, attempting to suppress unwanted emotions has been shown to increase distress and rumination (Abramowitz, Lackey, & Wheaton, 2009; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008; Wegner, Schneider, Carter, & White, 1987) whereas accepting these negative emotional states is known to improve emotional functioning (Abramowitz, 2013). As such, avoidance may inadvertently serve to maintain cognitive processes that underlie various forms of psychopathology, including substance use disorders, trauma- and stressor-related disorders, and anxiety disorders (S. C. Hayes, Wilson, Gifford, Follette, & Strosahl, 1996; Stewart, Zvolensky, & Eifert, 2002). In PTSD, for example, Marx and Sloan (2005) describe this avoidance-as-coping as "futile attempts to control internal experiences" which, if not processed, may result in increasingly more maladaptive attempts to distance oneself from the unwanted experience by means of substance use, suicidality, risk-taking, and aggression. Further compounding the avoidance of emotions, individuals with high levels of emotion dysregulation tend to react negatively to their own emotional experiences, for example, becoming angry and aggressive towards others or engaging in self-injurious behaviors when emotions seem too intense to bear (Cole, Michel, & Teti, 1994; Linehan, 1993). Attempts at controlling emotions, either by suppressing or avoiding them, can also elicit secondary emotions that are also difficult to regulate (e.g. feeling guilty about one's inability to "will oneself" to stop feeling depressed; (S. C. Hayes, Strosahl, & Wilson, 2002). Emotion dysregulation has also been associated with impulsive, reactive responses in the face of psychological distress (Weiss et al., 2012), which can prohibit effective communication and goal directed activity (Melnick & Hinshaw, 2000). When those individuals are not able to effectively regulate emotional distress, it can lead them to rely on those maladaptive, reflexive strategies and prevents the development of other, more effective emotion regulation strategies (Gratz & Roemer, 2004). Evidence also suggests that this disruption in one's regulative capacity is even more notable when high levels of emotion dysregulation are present in childhood when individuals typically develop emotion regulation strategies (Cicchetti & Toth, 1995; Shields & Cicchetti, 1998). Moreover, individuals who experience childhood maltreatment have particularly high levels of emotion dysregulation putting them further at risk for developing psychological sequelae (Cicchetti & Toth, 1995; Cloitre et al., 2010; Dunn, Nishimi, Powers, & Bradley, 2017; Zlotnick et al., 2003).

The diagnosis of Complex PTSD (Herman, 1992) was introduced to the ICD-11 as a way to classify this group of traumatized, emotionally dysregulated individuals. This diagnosis entails symptoms of emotion dysregulation, disturbed self-concept (including chronic shame) and interpersonal difficulties (van der Kolk, 2002) in addition to fulfilling the standard diagnostic criterion for PTSD. Extreme emotion dysregulation in the context of trauma can present in other ways as well, such as substance misuse (Brady, Back, & Coffey, 2004; Chilcoat & Breslau, 1998), binge eating (Felitti et al., 1998; Moulton, Newman, Power, Swanson, & Day, 2015), self-injurious behavior, and suicidality (van der kolk, Perry, & Herman, 1991). Furthermore, evidence suggests that these difficulties – chiefly, poor emotion regulation and lack of social supports from whom one can get assistance with emotion regulation – correspond with poor response to first-line PTSD treatments, namely, exposure-based therapies (Foa & Hearst-Ikeda, 1996; Ford, Courtois, Steele, Hart, & Nijenhuis, 2005). Taken all together, the literature has shown that high levels of emotion dysregulation can complicate clinical presentations of PTSD.

Just as Complex PTSD is associated with high emotion dysregulation, the dissociative subtype of PTSD has also been linked to high levels of dysregulation, particularly emotional disengagement (Lanius et al., 2012; Stovall-McClough & Cloitre, 2006). Studies indicate that PTSD subsequent to childhood abuse is highly comorbid with dissociative symptoms (Cloitre, Koenen, Cohen, & Han, 2002; Lanius et al., 2012; van der Kolk, Hostetler, Herron, & Fisler, 1994). In the most recent version of the Diagnostic and Statistical Manual (DSM-5), the American Psychological Association (2013) outlined how some patients present with marked dissociative symptoms (Friedman, Resick, Bryant, & Brewin, 2011). This dissociative subtype includes persistent and recurrent symptoms of depersonalization (*i.e.* feeling detached from one's body or mind) and/or derealization (*i.e.* feeling disconnected from one's present environment) or both (American Psychological Association, 2013). Moreover, patients who exhibit high levels of dissociative symptoms have contrasting patterns of physiological reactivity (*i.e.* blunted heart rate, skin conductance, and even cortical activation) as compared to PTSD patients with no dissociative symptoms (Felmingham et al., 2008; Hopper, Frewen, van der Kolk, & Lanius, 2007), which suggests that these symptom presentations have distinct correlates that could possibly be the result of distinct pathophysiology in response to trauma (Friedman et al., 2011; Lanius et al., 2010).

Under- and Over-modulation of Emotion in PTSD

As noted earlier, emotion dysregulation has different clinical presentations in traumatized people. In response to trauma-related cues (either internal or external), people with PTSD may show either a heightened or dampened emotional and physiological response. This phenomenon has been described as under- or over-modulation of emotion in recent conceptualizations of PTSD (Lanius et al., 2010). Emotional under-modulation has been described as a response style that is characterized by deficient inhibition of a conditioned fear response. This response style is associated with intrusive re-experiencing of the traumatic event (*e.g.* flashbacks) and heightened physiological reactivity to trauma-related stimuli (Lanius et al., 2010) and in established fear conditioning paradigms (Norrholm & Jovanovic, 2018). Over-modulation of emotion, on the other hand, has been described as excessive emotion inhibition (restriction) and emotional disengagement (Jaycox & Foa, 1996; Porges, 2007) – this response that has been associated with the dissociative subtype of PTSD (Lanius, Frewen, Tursich, Jetly, & McKinnon, 2015). With regard to psychophysiology, emotional over-modulation has been associated with blunted arousal in response to emotionally evocative stimuli, demonstrated via lower skin conductance, heart rate, and heart rate variability, or HRV, which is the between-beat variability in an individual's heart rate (Hauschildt, Peters, Moritz, & Jelinek, 2011; Lanius, Bluhm, Lanius, & Pain, 2006; Lemche et al., 2007). HRV has been conceptualized as a psychophysiological proxy for the autonomic response, which is the mechanism of autonomic nervous system the controls fight-or-flight response (Porges, 2007). This blunted physiological response is the opposite of what would typically be expected in those who show emotional under-modulation (Hinrichs et al., 2017).

Emotion Dysregulation and Self-efficacy

Overview of Self-efficacy

Patients with PTSD and emotion dysregulation at the extremes described above likely engage in maladaptive emotion regulation strategies when they perceive their emotions as overwhelming and uncontrollable (Bauer, Wiley, Weihs, & Stanton, 2017; Frewen & Lanius, 2006). As a result (as indicated by the diagnostic features of Complex PTSD), many traumatized individuals with high levels of emotion dysregulation show clinically significant disruptions in self-concept. Prominent feelings of guilt and worthlessness and low levels of self-efficacy in this population exemplify these disruptions in self-image (Bandura, Caprara, Barbaranelli, Gerbino, & Pastorelli, 2003; Cloitre, Garvert, Weiss, Carlson, & Bryant, 2014). Self-efficacy has been described as one's perceived ability to perform the necessary actions successfully in order to obtain the desired outcome (Bandura, 1977). Bandura (1977) outlined three core components of self-efficacy: 1) the self-perceived ability to identify a desired outcome in a given situation; 2) the self-perceived ability to mobilize the resources that are required to achieve that outcome; and 3) the incorporation of feedback from both prior experiences and current situations to help to predict outcomes.

For example, when faced with a challenge like a final exam, a student with high self-efficacy may set a high goal and expect to achieve that score based on her beliefs about her existing knowledge, her performance on past exams, and the amount she has studied and will study. Importantly, self-efficacy is different from the behaviors that are actually performed, and it has been shown to influence achievement even when controlling for performance itself

(Bandura & Locke, 2003). In the context of self-efficacy for emotion regulation, Chesney and colleagues (2003) describe this distinction as how much individuals believe they can engage in adaptive coping behaviors. Because it entails the perceived ability to mobilize the required resources (both internal and external, like motivation and social support, respectively), self-efficacy incorporates a self-reflection on the ability to overcome obstacles and barriers met on the way toward the goal. To that end, many measures of self-efficacy include phrases like "how confident are you that you can …" and "I am certain I can… " (Chesney, Neilands, Chambers, Taylor, & Folkman, 2006; Sherer et al., 1982). That is, those with high self-efficacy believe they have the resources to overcome any obstacles that may arise as they work toward a goal. This positive in-the-moment appraisal highlights the dynamic and context-dependent qualities of self-efficacy (Bandura, 1977). Information from past and current experiences are involved in this appraisal; for example, a woman completing a marathon may change her perceptions of her ability to finish once she is halfway through the race if it is easier or harder than she anticipated. Lastly, it is also worth noting that self-efficacy is best measured in specific contexts (that is, perceptions of ability to complete a specific task, like completing a marathon) and less effective when view globally. All together, these features situate self-efficacy as a part of general self-regulatory processes.

Self-efficacy and Self-Regulation

Self-efficacy is theorized to be a critical component of regulation of the self, including emotional and behavioral responses (Bandura, 1977). Self-regulation, like self-efficacy, is related to goal directed behavior (Hofmann, Schmeichel, & Baddeley, 2012). Hofmann and colleagues (2012) describe self-regulation as having three components: 1) an individual's preferred thoughts, behaviors and feelings; 2) motivation to minimize differences between actual experience and those ideals; and 3) the capacity to persist to achieve those ideals. Self-efficacy is similarly involved in goal setting and predicting obstacles encountered along the way (Bandura, 1991). While self-regulation reflects an individual's ability to achieve those outcomes, self-efficacy is related to perceived ability to succeed. However, these processes interact – those with higher levels of self-efficacy are thought to be more able to achieve more challenging goals (Bandura & Locke, 2003; Bouffard-Bouchard, 1990), and have set more challenging goals for themselves (Locke, Zubritzky, Lee, & Bobko, 1984). Individuals with higher self-efficacy have rated more difficult tasks as more achievable and reported less distress when given negative performance evaluations mid-task (Kanfer & Ackerman, 1989). Together with the evidence from Locke and colleagues (1984), these findings suggest that those with higher levels of self-efficacy both set and achieve more challenging goals for themselves, perhaps because they are better able to manage their distress through healthy coping strategies or by means of avoidance and denial. Relatedly, higher self-efficacy to regulate emotions has been shown to predict several areas of functioning including social relationships, academic performance, and mental health (Bandura et al., 2003). This evidence supports the theory that self-efficacy influences an individual's behaviors by means of its involvement in self-regulatory behaviors, such as setting goals and persisting through challenges in order to achieve desired results (Bandura, 1977, 1982; Peterson & Stunkard, 1989).

Self-efficacy and Heart Rate Variability

Heart rate variability has emerged as a physiological measure of self-regulation in the context of emotions (Thayer, Hansen, & Johnsen, 2010). Evidence suggests that individuals with higher self-efficacy also demonstrate higher levels of HRV. For example, two studies indicate that higher HRV was associated with increased ability to manage 1) life stress in school teachers

(Schwerdtfeger, Konermann, & Schönhofen, 2008) and 2) competition-related stressors in female athletes (Haney & Long, 1995). The underlying neurobiological theory of emotion regulation describes the capacity of the autonomic nervous system to adjust one's heart rate according to various demands including physiological and psychological states (Appelhans & Luecken, 2006; Porges, 2007). Some evidence suggests that low HRV be a biomarker of a risk factor for psychopathology (Thayer & Lane, 2009), as individuals with low HRV, according to this theory, also exhibit higher levels of emotion dysregulation (Porges, 2007). For example, one study of college students demonstrated that HRV negatively correlated with ruminative thinking after feedback that they failed an IQ test (Geisler & Kubiak, 2009). In a different study involving negatively valenced film clips, undergraduates with lower HRV showed negative facial expressions compared to those with higher HRV (Pu, Schmeichel, & Demaree, 2010) despite reporting feeling similar strength of negative emotions. Similar to self-efficacy, increased HRV positively predicted persistence at challenging and even impossible tasks (Segerstrom & Nes, 2007). Segerstrom and Nes (2007) have demonstrated that people who had better self-regulation have more dynamic HRV responses (*i.e*. based on one's current demands), further supporting the hypothesis that HRV is a marker of self-regulation. Indeed, a recent meta-analysis did find that HRV positively correlated with self-regulation (Zahn et al., 2016). As a result of this burgeoning research, HRV has been used to investigate several disorders involving emotion dysregulation including eating pathology (Friederich et al., 2006), substance abuse (Ingjaldsson, Laberg, & Thayer, 2003), and PTSD (Bhatnagar et al., 2013). Because of implications of the findings herein and above have on emotion regulation, self-efficacy has been investigated in psychiatric populations.

Self-efficacy and Emotion Regulation in Psychiatric Conditions

Indeed, low levels of self-efficacy have been associated with common symptoms of psychopathology (*e.g.* substance abuse, binge eating, and non-suicidal self-injury) as these impulsive behaviors are coping strategies designed to avoid unpleasant emotional states only to create subsequent future problems (Axelrod, Perepletchikova, Holtzman, & Sinha, 2011; Hasking & Rose, 2016; Selby & Joiner Jr, 2009). For example, adolescents at risk for mood and anxiety disorders who reported higher levels of self-efficacy (defined as confidence in ability to navigate stressful situations successfully) also reported fewer episodes of non-suicidal self-injurious behavior (Tatnell, Kelada, Hasking, & Martin, 2014). Furthermore, both women with binge eating disorder and a sample of college women taking introductory psychology courses reported fewer binges if they had also reported high levels of self-efficacy, which was operationalized as “self-competence” (Bardone-Cone, Abramson, Vohs, Heatherton, & Joiner, 2006; Etringer, Altmaier, & Bowers, 1989). Lastly, in a sample of patients treated for nicotine use disorder, those who reported having higher self-efficacy had longer latency to relapse (Condiotte & Lichtenstein, 1981). These studies indicate that self-efficacy may help to protect against the development of disorders characterized by emotion dysregulation (Bandura, 2012), and is thus an excellent treatment target for these problems.

Self-efficacy and PTSD

With regard to PTSD in particular, self-efficacy appears to play a role in resilience and risk for the development of this disorder (Flatten, Wälte, & Perlitz, 2008; Nygaard, Johansen, Siqveland, Hussain, & Heir, 2017). Higher levels of self-efficacy may buffer against the development of PTSD after experiencing a trauma. This has been shown in both cross-sectional (Benight et al., 2000; Benight & Harper, 2002; Ginzburg, Solomon, Dekel, & Neria, 2003; Regehr, Hill, Knott, & Sault, 2003) and longitudinal studies (Nygaard et al., 2017). For example, Regehr and colleagues (2003) studied firefighters and found that those with both lower levels of self-efficacy and lower perceived social support had higher levels of depression and traumatic stress. Ginzburg and others (2003) found that both self-efficacy and locus of control accounted for significant variance in discriminating between Israeli Veterans with PTSD and combat-exposed controls. Nygaard and colleagues (2017) found that both more severe PTSD symptoms were associated with decreased self-efficacy soon after an assault and levels of self-efficacy at one year after the assault predicted PTSD symptoms seven years later. Related to psychophysiology, individuals with PTSD have been shown to have lower heart rate variability, which is further suggestive of low distress tolerance (van der Kolk, 2006). One explanation for these findings is the association between self-efficacy and the "incompetent self" image (Resick, Monson, & Chard, 2007) that can emerge after experiencing a trauma. That is to say, patients with PTSD may feel incompetent and therefore are less willing to tolerate emotional distress, in turn, causing them to rely on avoidance as an emotion regulation strategy (Ehring & Quack, 2010). Avoidance and suppression, however, are ineffective coping strategies and may even increase perceptions of emotional distress (Abramowitz, 2013). Supporting this finding, studies have demonstrated that higher levels of self-efficacy correlate with lower PTSD symptom severity. Furthermore, cross-sectional, matched-control studies demonstrate that PTSD patients report lower self-efficacy when compared with peers who experienced similar levels of combat exposure (Solomon, Weisenberg, Schwarzwald, & Mikulincer, 1988) or childhood abuse (Saigh, Mroueh, Zimmerman, & Fairbank, 1995). These findings again illustrate that self-efficacy promotes resilience after trauma exposure (*e.g.* Southwick & Charney, 2012) and also indicate that low self-efficacy can contribute to the development and maintenance of PTSD.

Self-efficacy Mediating Treatment Response in Emotionally Dysregulated Populations

Given the relationship between emotion dysregulation and self-efficacy, it is unsurprising that self-efficacy has been linked to treatment outcomes in emotionally dysregulated populations (e.g. Silva et al., 2003). In intervention studies with substance use disorder populations, higher posttreatment self-efficacy has consistently been linked to both longer posttreatment abstinent periods and latency to relapse (T. G. Brown, Seraganian, Tremblay, & Annis, 2002; Litt, Kadden, Kabela‐Cormier, & Petry, 2008; Orbon, Mercado, & Balila, 2015). To this end, studies have demonstrated that self-efficacy mediated treatment outcomes in populations with high levels of emotion dysregulation, including patients with substance abuse or binge eating disorder (Borrelli & Mermelstein, 1994; Cervone, 2000). A randomized controlled trial comparing motivational enhancement against psychoeducation demonstrated that pretreatment self-efficacy mediated reductions in problematic drinking (LaChance, Feldstein Ewing, Bryan, & Hutchison, 2009). Self-efficacy has also mediated the effects of Relapse Prevention (a cognitive behavioral therapy for substance use disorders) on posttreatment substance use (T. G. Brown et al., 2002). Lastly, self-efficacy mediated the achievement of interim goals in smokers working toward abstinence (Borrelli & Mermelstein, 1994). In non-suicidal self-injurious populations, the empirical support is mixed, with some studies failing to find that self-efficacy mediated treatment response (e.g. Midkiff, Lindsey, Meadows, & Cerniglia, 2018), and others evincing a mediating role of self-efficacy (e.g. Heath, Joly, & Carsley, 2016). Taken altogether, however, evidence does support the hypothesis that self-efficacy plays an important role in treatment response in populations with high levels of emotional dysregulation.

Self-efficacy and Mindfulness Interventions

Mindfulness and Self-efficacy

Mindfulness-based interventions appear to target self-efficacy directly, making these treatments optimal for emotionally dysregulated populations (Chang et al., 2004; Leyland, Rowse, & Emerson, 2018; Sanaei, Hossini, & Jamshidifar, 2014; Teper, Segal, & Inzlicht, 2013). Mindfulness practices involve nonjudgmental awareness of one's present experience, however pleasant or distressing it may be (Kabat-Zinn & Hanh, 2009). Mindfulness skills training involves emotion awareness and acceptance while training attention to a single (often sensory) cue. This process is thought to facilitate goal-directed persistence in the face of distress (K. W. Brown, Ryan, & Creswel, 2007; Jimenez, Niles, & Park, 2010). Bishop and colleagues (2004) suggested that emotional acceptance may arise through more thoughtful, intentional (and similarly, less habitual and reflexive) responses to emotional states. Because mindfulness involves attending to one's present experience without judgment, mindfulness practices may empower individuals to experience distressing emotions rather than avoid them (Teper et al., 2013). In support of this notion, in studies of patients with cancer, increases in mindfulness skills correlate with increased distress management and higher posttreatment self-efficacy (K. W. Brown & Ryan, 2003; Sanaei et al., 2014). In patients with alcohol dependence, a mindfulness meditation intervention decreased both emotional suppression (*i.e.* avoidance) and reactivity to substance-related cues, which suggests that those patients were able to regulation distressing emotions more adaptively (Garland, Gaylord, Boettiger, & Howard, 2010). These studies demonstrate a link between mindfulness and self-efficacy and suggest that improving emotion regulation strategies underpin this relationship.

Mindfulness and Emotion Regulation

Mindfulness practices are designed to improve both emotion regulation and attentional control (Goldin & Gross, 2010; Neff & Germer, 2013). These practices facilitate emotion tolerance, decrease emotional avoidance, and enhance voluntary control of attention. Because of the prevalence of emotion avoidance (Stewart et al., 2002), emotion dysregulation (Jaycox, Foa, & Morral, 1998), and low self-efficacy (Foa & Rothbaum, 2001) in mood and anxiety disorders, both mindfulness- and acceptance-based interventions have been applied to these populations. Furthermore, self-efficacy has even been shown to mediate the effect of a mindfulness intervention in college students participating in research for course credit (Luberto, Cotton, McLeish, Mingione, & O'Bryan, 2013). Mindfulness-based interventions have been found to be efficacious for a variety of mood and anxiety disorders (Jiménez, 2012; Jimenez et al., 2010; Veehof, Oskam, Schreurs, & Bohlmeijer, 2011; Vøllestad, Nielsen, & Nielsen, 2012). The literature has also demonstrated that mindfulness improves both clinical and physiological responses associated with poor emotion regulation – including low HRV – in both psychiatric populations and healthy controls (Delgado-Pastor, Perakakis, Subramanya, Telles, & Vila, 2013; Garland et al., 2010). In sum, mindfulness-based interventions reliably enhance emotion regulation in clinical and healthy populations.

Mindfulness Interventions for PTSD

Because mindfulness skills promote emotion regulation and self-efficacy, these interventions have been utilized to help to treat PTSD. In trauma populations, growing evidence supports the use of mindfulness skills to reduce PTSD symptoms, including symptoms that reflect over-modulation (e.g., dissociation) and under-modulation (e.g., hyperarousal) of emotion (Boyd, Lanius, & McKinnon, 2018). Mindfulness skills training evince therapeutic gains in both group and individual formats in such populations (Gordon, Staples, Blyta, Bytyqi, & Wilson, 2008; Kimbrough, Magyari, Langenberg, Chesney, & Berman, 2010). Mindfulness-based groups have also been shown to be more effective at reducing PTSD symptoms when compared with other group interventions (*e.g.* psychoeducation, cognitive-based skills) as well (King et al., 2013; Polusny et al., 2015). And in a population similar to the one examined herein (low-income, African-American women with trauma histories), mindfulness skills training resulted in qualitative improvements to PTSD symptoms, emotion regulation, and self-efficacy (Bermudez et al., 2013; Dutton, Bermudez, Matas, Majid, & Myers, 2013). These findings demonstrate that mindfulness-based treatments are effective at reducing PTSD symptoms and improving self-efficacy in patients with PTSD. Furthermore, mindfulness-based interventions have also been shown to be helpful for individuals with trauma histories and high levels of emotion dysregulation (Cloitre, Courtois, et al., 2012).

Mindfulness in Treatments for PTSD with Emotion Dysregulation

Because increasing mindfulness has been shown to decrease PTSD symptoms and to increase self-efficacy, mindfulness skills have been incorporated into treatments for patients with PTSD and high levels of emotion dysregulation (e.g. Cloitre et al., 2002; Linehan, Suarez, & Allmon, 1991). Mindfulness interventions can help reduce negative rumination and emotion avoidance while promoting emotional acceptance (Campbell-Sills, Barlow, Brown, & Hofmann, 2006; Kabat-Zinn & Hanh, 2009). As such, mindfulness may allow patients to experience emotions as less overwhelming, which in turn may help them learn to manage their emotional distress more adaptively (Cloitre, Petkova, Wang, & Lu (Lassell), 2012; van den Hurk, Giommi, Gielen, Speckens, & Barendregt, 2018; van den Hurk, Janssen, Giommi, Barendregt, & Gielen, 2010). Furthermore, the literature has demonstrated that acceptance of negative emotions reduces long-term distress (Eifert & Heffner, 2003), whereas emotional avoidance actually increases distress in the long run (Abramowitz, 2013; Abramowitz et al., 2009), particularly after a potentially traumatic event (Thompson, Arnkoff, & Glass, 2011). By experiencing emotional distress without actively making efforts to avoid these emotions or without feeling out of control, patients learn to endure strong emotional reactions and thereby increase self-efficacy; doing so is critical to effective trauma-focused therapy as both over- and under-engagement with emotion impedes therapeutic benefit (Jaycox & Foa, 1996). In order to manage the effects of emotion dysregulation to treat PTSD effectively, three interventions have incorporated mindfulness-based techniques to treat patients with PTSD and high levels of emotion dysregulation.

Skills Training in Affective and Interpersonal Regulation and Narrative Story Telling (STAIR/NST)

Cloitre and colleagues (2002) developed a phased intervention entitled Skills Training in Affective and Interpersonal Regulation and Narrative Story Telling (STAIR/NST) for patients with childhood trauma histories. The STAIR/NST approach incorporates components of mindfulness including emotional awareness and acceptance in order to give patients the necessary emotion regulation skills needed to engage effectively in the second, exposure-based phase of intervention. One of the main objectives of STAIR is to increase self-efficacy in order to help patients to confront trauma memories (Silva et al., 2003). STAIR/NST is efficacious in reducing both trauma and dissociative symptoms, particularly in those with high levels of dissociation (Cloitre et al., 2002).

Dialectical Behavior Therapy with DBT Prolonged Exposure (DBT-PE)

Another intervention, developed by Harned and colleagues (2012) combined the mindfulness skills training in Dialectical Behavioral Therapy, or DBT (Linehan, 1993), with elements of Foa and colleagues' (2007) exposure-based intervention to treat patients with comorbid PTSD and borderline personality disorder (BPD). DBT incorporates elements of mindfulness, acceptance, and emotion regulation, and these skills are helpful in reducing extreme emotional responses exhibited by patients with borderline personality disorder (Linehan et al., 1991; Verheul et al., 2003). In a small sample, this combined protocol resulted in reductions in non-suicidal self-injury, dissociation, and PTSD symptoms (Harned et al., 2012).

Trauma Center Trauma Sensitive Yoga (TCTSY)

Lastly, van der Kolk and colleagues (2014) developed trauma-sensitive yoga (Trauma Center Trauma-Sensitive Yoga, TCTSY), which was designed to use mindfulness skills to improve attention and awareness of cued bodily in patients with PTSD. This intervention has also been effective in reducing both trauma and dissociative symptoms (Price et al., 2017; van der Kolk et al., 2014). TCTSY has also been shown to increase patients' self-reported self-efficacy (Price et al., 2017).

While all three of these interventions have been effective in this subgroup of patients with PTSD and high levels of emotion dysregulation, little is known about the mechanism through which mindfulness imparts therapeutic benefits in these interventions. The majority of the studies involving interventions developed for patients with PTSD and high levels of emotion dysregulation have focused on reducing PTSD symptoms, yet few have examined mechanisms through which these changes arise. One possible mechanism is through changes in self-efficacy. Evidence also suggests that self-efficacy impacts intervention outcomes for survivors of trauma (Saigh et al., 1995; van der Kolk et al., 2014) and for emotionally-dysregulated populations (LaChance et al., 2009; Silva et al., 2003). Similarly, mindfulness-based interventions have been shown to increase self-efficacy (Grossman, Niemann, Schmidt, & Walach, 2004), and have been beneficial for populations with PTSD and high levels of emotion dysregulation (Cloitre et al., 2002; Harned et al., 2012). Self-efficacy has previously been shown to mediate treatment outcomes in populations with substance use (Borrelli & Mermelstein, 1994; T. G. Brown et al., 2002). However self-efficacy has yet to be examined as a mediator of treatment response in patients with PTSD and high levels of emotion dysregulation.

Self-efficacy as a Potential Mediator of Treatment Response in Populations with Trauma and Emotion Dysregulation

A group of patients with PTSD also exhibit clinically significant levels of emotion dysregulation (Cloitre, Courtois, et al., 2012). These patients experience their emotions as overwhelming and uncontrollable, leading to engagement in coping strategies marked by emotional avoidance or over-reactivity (Lanius et al., 2010). Evidence also suggests high levels of emotion dysregulation that they experience are deleterious for their self-appraisals of their abilities to succeed, or their self-efficacy (Bandura, 2012). The association between PTSD symptoms and lower levels of self-efficacy is well-established (see Luszczynska, Benight, & Cieslak, 2009). Mindfulness-based interventions have been shown to enhance self-efficacy (Chang et al., 2004) and emotion regulation (Jimenez et al., 2010), including HRV (Garland et al., 2010), as well as improving posttraumatic symptomatology (Boyd et al., 2018). Although evidence supports the role of self-efficacy in mediating treatment outcomes in populations with high levels of emotion dysregulation (such as eating disorders or substance use disorder), no extant studies to my knowledge have examined self-efficacy as a mediator of response to treatment in trauma populations to date. However, self-efficacy appears to be critical in PTSD treatment outcomes (Foa et al., 2007; Resick et al., 2007). Furthermore, data from non-intervention studies support the theory that self-efficacy is associated with changes in PTSD symptoms (Nygaard et al., 2017) and post-trauma self-efficacy predicts later conversion to PTSD (Flatten et al., 2008).

While self-efficacy is heavily implicated in the development and maintenance of PTSD, this important mechanism has not yet been examined as a mediator of response to a mindfulness-based PTSD treatment. This study aimed to utilize convergent self-report measures and psychophysiological data (HRV) in order to investigate whether or not self-efficacy was a casual mechanism for response to a mindfulness treatment through self report measures of emotion dysregulation and PTSD symptoms, as well as psychophysiological signs (HRV). I hypothesized that the change coping self-efficacy would mediate the relationships between pre- and posttreatment PTSD symptoms, pre- and posttreatment emotion dysregulation; and pre- and posttreatment HRV. I also hypothesized that the mediating effect of change in coping self-efficacy on the pre- and post-treatment PTSD relationship would be moderated by pretreatment emotion dysregulation.

Methods

Participants and Recruitment

Participants were women recruited from an ongoing randomized control trial (RCT) examining the effects of a vibroacoustically-augmented BFMM intervention on dissociation and PTSD symptoms (Physiological Augmentation of Mindfulness Meditation, NCT02754557). Emory's Institutional Review Board had approved this study and other Grady Trauma Project studies through which recruitment occurs (IRB00002114, IRB00009375, and IRB00085711). Participants for this study are recruited through two avenues. Chiefly, most participants were recruited from among a larger group of participants of the Grady Trauma Project – a study of trauma and sequelae in African-American women. These participants were approached at random in the waiting rooms of various clinics (*e.g.* Primary Care, Pharmacy, Ob/Gyn) of Grady Memorial Hospital. If a person expressed interest in participating, she underwent an informed consent procedure with study staff and subsequently completed a brief battery of questionnaires to assess mental and physical health including trauma exposure and PTSD symptoms. The second method for recruiting patients was from the community at large by means of flyers posted in areas around Grady Memorial Hospital, Emory's Brain Health Center, and the campuses of Georgia State University and Emory University. All participants were screened over the phone to assess eligibility for this study. Exclusion criteria for Grady Trauma Project studies were as follows: 1) younger than 18 years of age or older than 65 years of age; 2) presently at risk for suicide, actively psychotic, or intellectually disabled. Inclusion criteria for the Grady Trauma Project studies were the following: 1) does not meet for any exclusion criteria; 2) identifies as African-American or Black (mixed ethnicity is acceptable); 3) identifies as female. It is important to note that, since this project recruited from the Grady Trauma Project, the majority of this study's participants identified as African-American, though this was not a direct inclusion criteria for this study. Participants were then selected for the intervention study based on the following inclusion criteria: 1) experience of at least one Criterion A event; 2) presence of current PTSD symptoms (defined as meeting criteria for at least two of the four other PTSD criteria), and 3) willingness to participate in the study. Exclusion criteria for the intervention study were the following: 1) diagnoses of HIV/AIDS or other disorders that affect the central nervous system; 2) a history of bipolar disorder, schizophrenia or primary psychotic disorder; 3) a history of neurological conditions or injuries including strokes, seizures, and traumatic brain injury. Participants who were recruited from the community adhere to these criteria with the exception that they do not need to identify as Black or African-American.

Mindfulness Intervention Procedures

After the initial screening and consent for this intervention study, participants received a psychodiagnostic interview to confirm PTSD diagnosis and to rule out exclusionary study diagnoses (e.g., bipolar disorder) performed by study staff under the supervision of licensed psychologists. After completing this interview, participants were then randomized into one of two breath-focused mindfulness treatment conditions. The control group received the brief, computerized breath-focused mindfulness meditation (BFMM). The experimental group received a vibroacoustically-augmented BFMM. At each of six intervention visits over approximately three weeks, participants sat in a chair in a sound attenuated chamber in front of a computer screen, while being monitored by a researcher. Instructions appeared on the screen, which instructed them to either engage in BFMM (breathe into the microphone, focus on breath away from the microphone), or rest, for 1 minute in each condition. These conditions were randomized; the total session time was 15 minutes. The microphone was connected to a transducer, which translated the auditory signal into a bass shaker device that was worn like a pendant on the sternum. Study staff ensured that the participant understood the instructions fully prior to starting data collection. For those receiving the vibroacoustic augmentation of BFMM, breathing into the microphone resulted in a vibration on their sternum that was proportional to her breath; those who were in the non-augmented group wear the same device but receive no vibratory feedback.

Clinical Assessments

Self-report Measures for Proposed Aims

Difficulty in Emotion Regulation Scale. The Difficulty in Emotion Regulation Scale (DERS; (Gratz & Roemer, 2004) is a 36-item self-report scale that assesses emotion dysregulation in six factors: lack of awareness of emotional response, lack of clarity of emotional response, nonacceptance of emotions, lacking effective emotion regulation strategies, difficulties controlling impulsive behaviors when distressed, and difficulties engaging in goal-directed behaviors when distressed. The DERS was initially validated using college-aged healthy controls as well as patients with BPD, and has demonstrated strong internal consistency ($\alpha = .93$) and good test-retest reliability ($\rho_I = .88$; (Gratz & Roemer, 2004). The DERS total score is the primary outcome measure of emotion dysregulation that was be entered into statistical analyses.

Modified PTSD Symptom Scale. The Modified PTSD Symptom Scale (MPSS; (Falsetti, Resnick, Resick, & Kilpatrick, 1993) is a 17-item self-report scale to measure the frequency and intensity of current (past two weeks) PTSD symptoms. The scale is widely used, and has been validated on a variety of populations (clinical and community) who have experienced a wide range of Criterion A events (Falsetti, Resick, Resnick, & Kilpatrick, 1992). The MPSS is the primary outcome measure of PTSD symptom severity.

Coping Self-efficacy Scale. The Coping Self-efficacy Scale (CSES; (Chesney et al., 2006) is a 26-item self-report measure that assesses one's ability to engage in coping behaviors when confronted with challenges. The measure was validated in two randomized control trials investigating treatment efficacy in a population of men who have sex with men (Chesney et al., 2006), and has also been used in community samples (Nicholls, Polman, & Levy, 2010). The CSES has three subscales: 1) problem-focused coping; 2) stopping unpleasant emotions and thoughts; and 3) getting support from family and friends. The CSES is the primary outcome measure for coping self-efficacy.

Additional Clinical Measures Collected with the Parent Study

Participants complete several other self-reports as part of the larger parent study.

Multiscale Dissociation Inventory. The Multiscale Dissociation Inventory (MDI) (Brière, 2002) is a 30-item self-report measure of dissociative symptoms. Psychometric evidence suggests that dissociation has several dimensions (Brière, 2002; Lanius et al., 2010), including disengagement, emotional constriction, depersonalization, and derealization. The measure was validated in clinical, community, and combined samples, and has shown good internal consistency reliability ($\alpha = 0.96$; (Taft, Resick, Watkins, & Panuzio, 2009) and convergent validity with other measures of dissociation (all R^2s > 0.63; (Briere, Weathers, & Runtz, 2005).

Kentucky Inventory of Mindfulness Skills. The Kentucky Inventory of Mindfulness Skills (KIMS; (Baer, Smith, & Allen, 2004) is a 39-item self-report measure of participant's ability to engage in mindfulness skills. The measure and underlying model have been validated in two clinical samples with a range of psychopathology (Baum et al., 2010).

Beck Depression Inventory Version II. The Beck Depression Inventory version II (BDI-II; (Beck, Steer, & Brown, 1996) is one of the most widely-used self-report measures of depressive symptoms. The BDI-II comprises of 21 items; the measure has been shown to be a valid tool for assessing depression (Kjærgaard, Arfwedson Wang, Waterloo, & Jorde, 2014).

Multidimensional Assessment of Interoceptive Awareness. The Multidimensional Assessment of Interoceptive Awareness (MAIA; (Mehling et al., 2012) is a self-report measure of interoceptive body awareness with 32-items that measure eight constructs. One study of confirmatory factor analysis demonstrated that three MAIA subscales (Attention Regulation, Emotional Awareness and Body-Listening) correlated moderately (.41, .44, and .54) with the DERS Awareness subscale (Mehling et al., 2012). The MAIA has been shown to have acceptable construct validity; however, two subscales suggest that some of the three- or fouritem subscales (Not Worrying and Not Distracting in particular) had lower than desired levels of internal consistency (Mehling et al., 2012; Valenzuela-Moguillansky & Reyes-Reyes, 2015).

State Mindfulness Scale. The State Mindfulness Scale (SMS; (Tanay & Bernstein, 2013) is a self-report measure that assesses state-level mindfulness. The scale's developers demonstrated participants who were randomized to receive mindfulness training reported SMS scores higher than those reported at baseline but only during the four weeks of mindfulness training, while those randomly assigned to the assessment-only control condition saw no change in SMS scores (Tanay & Bernstein, 2013).

Measures from Psychodiagnostic Interview

Clinician Administered PTSD Scale for DSM-5. The Clinician Administered PTSD Scale for DSM-5 (CAPS-5; (Weathers et al., 2013) is the clinician-rated assessment for PTSD prior to DSM-5 recommended by the National Center for PTSD (Weathers et al., 2018). The CAPS-5 has been shown to be valid and reliable (Weathers et al., 2018).

Mini International Neuropsychiatric Interview. Selected modules from the Mini International Neuropsychiatric Interview (MINI; (Sheehan et al., 1998) including mood disorders, substance use, and psychotic disorders are also administered. The MINI is a widely used, clinician-administered diagnostic assessment developed by World Health Organization researchers for brief neuropsychiatric assessment in multisite clinical settings. Evidence has shown that the MINI can provide the same information as other diagnostic assessments with less of a time burden (Sheehan et al., 1998).

Posttraumatic Avoidance Behaviour Questionnaire. The Posttraumatic Avoidance Behaviour Questionnaire (PABQ; (van Minnen & Hagenaars, 2010) is a 25-item measure assessing commonly avoided behaviors after experiencing trauma. The measure was shown to have adequate internal consistency and retest reliability, and, importantly, to be sensitive to changes made in treatment.

Attentional Control Scale. The Attentional Control Scale (ACS; (Derryberry & Reed, 2002) is a widely-used measures of one's perceived ability to regulate attention. Evidence suggests adequate predictive and convergent validity with measures and behavioral tasks (Judah, Grant, Mills, & Lechner, 2014).

Psychophysiological Measures

Electrocardiogram

During all six intervention visits, electrocardiogram (ECG) data were collected throughout the duration of the session. Two leads were placed on the left radial pulse (wrist) and right carotid pulse (neck) in order to collect data via AcqKnowledge software (BIOPAC MP150/160 System, Inc., Goleta, CA, USA). All data was saved to a shared server.

Heart Rate Variability Data Analysis

HRV data were preprocessed by means of a previously validated and described MATLAB script obtained by study collaborator Dr. Greg Siegle, and documented in (Rabellino et al., 2017). This MATLAB software also utilized MATLAB HRVAS toolkit (developed by J Ramshur, and available on GitHub). As the authors note in Rabellino and colleagues (2017):

> High-frequency heart rate variability (HF-HRV) is a non-invasive measure … reflecting the flexible adaptation of physiological and emotional responses to momentary needs. Critically, lower HF-HRV has been found in individuals with PTSD, both at baseline and in response to trauma-related cues (p. 4899).

High-frequency HRV data (as outlined by Shaffer & Ginsberg, 2017) were utilized in these analyses as has been shown to correlate with factors of interest such as PTSD (e.g. Hauschildt et al., 2011) and mindfulness (e.g. Mankus, Aldao, Kerns, Mayville, & Mennin, 2013). Heart rate variability data was gathered by means of electrocardiographic measurements via leads (BIOPAC Systems, Inc.) on the radial and carotid arteries. HRV data was collected throughout the fifteen-minute visit. Data was smoothed and the QRS complexes were identified with the MATLAB script. Data for HRV was checked for quality assurance (QA). QA values were set as follows: heart rate between 40 and 120 beats per minute, without significant abrupt spikes or ectopic beats; electrocardiograms that appeared normative with distinct *R peaks* and *QRS complexes*. The QRS complex corresponds with the depolarization of the ventricles and subsequent contraction (R peak) of the ventricular muscles. Participants' sessions that fell outside expected values (*i.e*. fail QA) were subsequently manually checked and either corrected if possible or removed from analyses. Lastly, all HRV data files were then rechecked manually in order to correct any minor errors and to confirm inclusion/exclusion of the data file. After passing QA, data was aggregated thusly: each of the five blocks of one condition type were averaged at each millisecond of the minute-long trial to yield three (one per condition), one-minute-long timeseries of averages of the frequency-domain HRV data.

Data Analytic Plan

Aim 1 – Coping Self-efficacy as a Mediator of Change in both PTSD Symptoms and Emotion Dysregulation

The first aim of this study was to investigate the role of coping self-efficacy as a mediator of change in PTSD symptoms and emotion dysregulation after the BFMM intervention. I hypothesized that coping self-efficacy would significantly mediate the relationship between pre- and posttreatment PTSD symptoms, as measured by the MPSS (Aim 1a). I also hypothesized that coping self-efficacy would significantly mediate the relationship between pre- and posttreatment emotion dysregulation more generally, as measured by the DERS (Aim 1b). See Figures 1a and 1b.

Aim 2 – Correlation Between Changes in HRV and Changes in Coping Self-Efficacy, Emotion Dysregulation and PTSD

The second aim of this study was to examine the relationship between changes in HRV and changes in other variables of interest, including coping self-efficacy, emotion dysregulation, and post-traumatic symptomatology. I hypothesized that changes in HRV would correlate positively with the change in coping self-efficacy (CSES) and negatively with changes in both emotion dysregulation (DERS scores) and PTSD symptoms (MPSS).

Aim 3 – Coping Self-efficacy as a Mediator of Change in HRV During Breath-focused Mindfulness Condition

The third aim of the study was to examine the role of self-efficacy in mediating changes in HRV. Because HRV has been shown to be a psychophysiological proxy for autonomic response, I hypothesized that self-efficacy would significantly mediate the relationship between pre-and posttreatment HRV during the breath-focused condition. High frequency HRV – that is, activity within the 0.15Hz to 0.40Hz range – was utilized in the proposed aims. See Figure 2.

Exploratory Aim 4 – Pretreatment Emotion Dysregulation Moderating the Mediating Effect of Change in Coping Self-efficacy

As an exploratory aim, moderated mediation was examined to determine whether or not the change in coping self-efficacy affects changes in PTSD symptoms (MPSS scores) differentially based on severity of emotion dysregulation (pretreatment DERS scores). I hypothesized that the mediating effects of coping self-efficacy (CSES) on the relationship between pre- and posttreatment PTSD symptoms would be moderated by pretreatment emotion dysregulation (DERS), with those having less emotion dysregulation evincing larger indirect effects. See Figure 3.

Covariates

Variables that may influence the hypothesized relationships between symptomatology (MPSS, CSES, *et al*.) and psychophysiology (*i.e*. HRV) include receiving the vibroacoustically-augmented BFMM (*i.e.* experimental condition) and practicing BFMM outside of study sessions. Given that this study is a randomized control trial, we have *a priori* hypotheses regarding the effects of the augmented BFMM condition. Additionally, study staff monitored participants' practicing the breathing techniques outside of the computerized training sessions (which was not suggested or required but was monitored by self-report) as these skills have been shown to be efficacious both in reducing emotional distress and trauma-related symptoms and in increasing HRV as outlined above (*e.g.* Bhatnagar et al., 2013). Practice amount was tabulated by means of an ordinal scale (0-3) each week, with the options of "none," "less than twenty minutes," "between twenty to fifty minutes," and "more than fifty minutes," respectively.

***A Priori* Power Analysis**

An *a priori* power analysis was conducted using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) to determine the number of participants needed for this analysis. The statistical inputs were the following: $\alpha = 0.05$, $1\text{-}\beta$ of 0.8, and an $f^2 = 0.20$. The effect size was a conservative estimate based on the findings of coping self-efficacy mediating the effects of intervention for at-risk substance use, $f^2 = 0.51$ (T. G. Brown et al., 2002); a longitudinal survey study examining conversion to PTSD after a natural disaster, $f^2 = 0.24$ (Benight & Harper, 2002); and a study examining predictors of abstinence after a smoking cessation group, $f^2 = 0.15$ (Borrelli & Mermelstein, 1994). Using G*Power to calculate the sample size needed for a multiple linear regression with three predictors (*e.g.* pretreatment MPSS score, change in CSES scores, and the indirect pathway in mediation) was used. The total sample size required that was returned by the software was 59, which would result in an achieved power of 0.80.

Proposed Analysis for Study Aims

To examine the mediator outlined this study's primary aim, data underwent conditional path analyses (A. F. Hayes, 2013) in a mediation model by means of the PROCESS macro (version 3.5) for IBM's SPSS Statistics (version 26.0.0.0), which is distributed by the author online. The PROCESS macro calculates the effects of the predictor (e.g. PTSD symptoms measured by MPSS score at pretreatment) on the outcome variable (e.g. PTSD symptoms measured via MPSS at posttreatment) through the indirect effects of the proposed mediator in this model (change in CSES score). The macro is also able to examine moderated mediation, and thus will be used for all four proposed aims.

The PROCESS macro then infers the significance of the proposed indirect effects of the mediator by means of bias-corrected bootstrapping of confidence intervals. The latter methodology is the recommended approach for examining a mediator's significance in studies limited by small sample size because it is better able to account for the biases associated with non-normal distributions (Cheung, 2009; A. F. Hayes & Scharkow, 2013; Preacher & Hayes, 2004). PROCESS's bootstrapping method works thusly. The macro will resample the original population *n* times in order to evaluate the indirect effect of the predictor on the outcome variable by way of the mediator. For study aims, 10,000 bootstrapped samples of the original sample were used to create 95% confidence intervals. These confidence intervals are then corrected by the macro for any bias in the bootstrapped sample's distribution, and were subsequently be considered to be significant if the range of the confidence interval did not include zero.

Results

Demographics

Only data from participants who completed the CSES at both pretreatment and posttreatment were included for analysis (*n* = 46). These 46 participants represent 83.6% of the 55 total participants who completed the intervention when data was collected for this project.

All participants self-identified as female. Forty-one participants (89.1%) self-identified as Black/African-American, two as White/Caucasian (4.3%), one as Hispanic (2.2%), and two as "Other" (4.3%). The average age of participants was 43.9 (SD = 12.6), with the oldest being sixty-three and youngest being eighteen. Regarding educational attainment, six participants (13.0%) did not complete high school; twelve (26.1%) completed high school or equivalent; eight completed some secondary education (17.4%); five completed technical or trade school (10.9%); twelve (26.1%) graduated college; and three (6.5%) obtained graduate degrees. Thirty participants (65.2%) were unemployed. Twenty-seven (58.7%) of participants received the active (*i.e.* augmented) intervention. These participants averaged a little more than 10 minutes of practice each week (1.13, which equates to about 12-15 minutes of practice per week). See Table 1.

Summary of Clinical Measures (See Table 1 and Figure 4)

Modified PTSD Symptom Scale

All 46 participants completed the MPSS at pretreatment and posttreatment. The pretreatment scores (*e.g.* Session 1) on the MPSS ranged from 13 to 50 and averaged 28.0 (*SD* =

8.52). The average posttreatment (Session 6) score was 19.7 (*SD* = 12.2) and ranged from 0 to 51.

Beck Depression Inventory – Version II

Data was available for all 46 participants' pretreatment and posttreatment BDI-II. The pretreatment scores on the BDI-II ranged from 5 to 53 and averaged 25.6 (*SD* = 11.6). The posttreatment scores ranged from 0 to 53 and had an average of 17.4 (*SD* = 11.5). The distribution of the data was significantly non-normal at posttreatment: *z*(skew) = 2.86 and *z*(kurtosis) = 1.68. Using Tukey's power ladder approach (Tukey, 1977), square-root transformations were found to normalize both pretreatment and posttreatment BDI scores sufficiently. Doing so created normality of distributions within tolerability limits: at pretreatment, *z*(skew) = -0.39 and *z*(kurtosis) = -0.48, and at posttreatment, *z*(skew) = 0.64 and *z*(kurtosis) = 0.83.

Coping Self-Efficacy Scale

These 46 participants completed the CSES at both pretreatment and posttreatment timepoints. The pretreatment scores on the CSES ranged from 10 to 235 and averaged 137.4 (*SD* = 57.4). For the posttreatment CSES, the average was 165.1 (*SD* = 62.9), and the range was 11 to 252. No transformation resulted in a sufficiently normal distribution, and one outlier (greater than two standard deviations below mean) was removed from the dataset, resulting in a tolerable distribution (*z*(skew) = -0.89 and -1.86, *z*(kurtosis) = -0.99 and -1.04 respectively). This participant's data was excluded from all analyses involving the CSES.

Multiscale Dissociation Inventory

All of these participants completed the MDI pretreatment, yielding a range of 32 to 129, and an average of 59.7 (*SD* = 19.1). The average of these 46 participants' posttreatment MDIs was 48.9 (*SD* = 15.5). The distribution of the data was significantly non-normal: at pretreatment, *z*(skew) = 4.75 and *z*(kurtosis) = 5.31, and at posttreatment, *z*(skew) = 4.60 and *z*(kurtosis) = 5.11. Resultantly, the MDI scores were transformed and the reciprocal-root transformations (*i.e.* raising the value to the negative one-half power) normalized the data the best. This transformation sufficiently normalized the data (*z*(skew) = -0.61 and -1.23; and *z*(kurtosis) = 0.42 and -0.41, respectively). *NB*: after a reciprocal-root transformation, values will become negative but changes in scores are not inverted: for example, a reduction of 63 points on the MDI yields a reduction in 0.053 on the transformed MDI.

Difficulty in Emotion Regulation Scale

Forty-one participants completed the DERS pretreatment, and only eighteen had posttreatment DERS data available due to the measure being added to the posttreatment battery after data collection had initiated. The pretreatment scores ranged from 50 to 145 and averaged 88.1 (*SD* = 26.2). At posttreatment, the range was 44 to 141, and the average DERS score was 93.1 (*SD* = 29.7).

Kentucky Inventory of Mindfulness Skills

All participants in this group completed the KIMS pretreatment and posttreatment. The pretreatment scores ranged from 62 to 154 and averaged 119.5 (*SD* = 19.7). The posttreatment scores averaged 124.8 (*SD* = 19.9) and ranged from 64 to 155. Due to non-normal distribution of the pre- and posttreatment KIMS score (*z*(skew) = -2.59 and -3.78; *z*(kurtosis) = 2.30 and 2.95, respectively) both the pretreatment and posttreatment KIMS scores were subjected to transformations via Tukey's ladder of power (Tukey, 1977). This process did not sufficiently normalize the data, so data points with the highest leverage were removed and the process was repeated until three participants' data was excluded. With those datapoints excluded, the data no longer needed any transformation to be within limits of normality (pretreatment: *z*(skew) = -1.17, and *z*(kurtosis) = 1.82; posttreatment: *z*(skew) = -0.97, and *z*(kurtosis) = -0.63). Resultantly, analyses were conducted with and without these three participants' data.

Multidimensional Assessment of Interoceptive Awareness

All 46 participants also completed the MAIA at both timepoints. The pretreatment scores the MAIA ranged from 39 to 140 and averaged 92.0 (*SD* = 24.6). The average posttreatment score was 111.13 (*SD* = 27.6), with a range of 25 to 147. Due to non-normal distribution of the posttreatment MAIA score (*z*(skew) = -2.25) both the pretreatment and posttreatment MAIA scores were log-transformed. Even after transforming the data as previously outlined, one of the participants (who was the first participant to be excluded based on KIMS data) was removed and the process was repeated. After doing so, the data no longer needed transformation (*z*-scores for skew and kurtosis within +/- 1.96). That participant was removed from analyses that utilize the MAIA as well.

Heart Rate Variability

Only data from the breath-focused condition – the active experimental condition – were utilized in analyses in order to examine the direct effects on mindfulness engagement on HRV. Importantly, some participants did not receive the active control condition (engaging in mindfulness without the vibroacoustic feedback). The breath-focused blocks' average heart rate variability data for both session one and session six were available for 31 participants. Several factors accounted for missing data: hardware malfunction resulting in irrecoverable raw data loss, coding errors that resulting in inaccurate timing of block triggers to be generated incorrectly, and cases of insufficient data quality for reliable isolation of QRS complexes. Participants whose data was present for only either session one or session six were also excluded, as change scores were utilized in some analyses. The data ranged from -1.33 standard units (su) to 1.19su, and the mean was 0.03 (*SD* = 0.59). At session six, this HRV data ranged from –1.20su to 1.04su, and the mean was -0.05su (*SD* = 0.54).

Statistical information (*e.g.* mean, standard deviation) for these measures is available in Table 1. Information is presented on the whole sample (*n*=46) as well as information for each variable after outliers were removed.

Correlations among Clinical Variables

The participants whose data were excluded to create normal distributions were not included in these analyses, resulting in 42 participants included in these correlation analyses. The correlations with HRV data only included the 29 participants with both pre- and posttreatment HRV data: two of the excluded datapoints were among the thirty-one who had data at both timepoints. Three of the excluded participants were also among the forty-one who had pretreatment DERS resulting in DERS data from thirty-eight participants being included in the pretreatment correlation analysis. Additionally, two of the four excluded participants were among the eighteen who had posttreatment DERS, resulting in seventeen participants' DERS data included in the posttreatment correlation analyses.

Pretreatment

The average HRV from the breath-focused condition during Session one did not correlate with any self-report measures (see Table 2). Pretreatment MPSS significantly correlated with BDI, MDI, DERS, and CSES. Moderate (using guidelines from Dancey & Reidy, 2007) associations in the expected direction were found among the BDI-II, CSES, MDI, and DERS. Pretreatment CSES correlated significantly with all other self-report measures except the KIMS, all in expected directions. The correlation was strong with the BDI-II and DERS, and moderate with the MPSS and MAIA, and weak with the MDI. The participants' pretreatment DERS data significantly correlated with the all other self-report data except the MAIA. The direction of the correlation between the DERS and KIMs was unexpectedly positive, meaning that higher emotion dysregulation scores corresponded to higher trait mindfulness scores. The remaining correlations between the DERS and other self-report measures were in the expected directions: negative with the CSES and positive with MPSS, BDI-II, MDI. The correlations were strong with the BDI-II and CSES, moderate with the MPSS and MDI, and weak with the KIMS. See Table 2 for full correlation table.

Posttreatment

The average HRV from the breath-focused condition during Session six also did not correlate significantly with any self-report measures (see Table 3). The posttreatment MPSS significantly correlated in the expected directions with the all other self-report measures except the KIMS. The correlation with the BDI-II was strong. The correlations with the DERS and MDI were moderate. The relationships with the CSES and MAIA were weak. The correlation with the KIMS was unexpectedly positive, but the other correlations were in the expected directions. The posttreatment CSES significantly correlated with all other posttreatment self-report measures except for the KIMS. The correlations with the BDI-II and DERS were strong. At posttreatment, the CSES correlated strongly with the DERS and MAIA, moderately with the BDI-II and MDI, and weakly with the MPSS. These five significant correlations were in the expected directions. The posttreatment DERS scores (n=17) correlated strongly with the BDI-II and CSES, and moderately with the MPSS and MDI. These four correlations were in expected directions. See Table 3 for full results.

Effects of Treatment on Clinical Measures

Since transformed data were used in these analyses, changes in measures were reported by percent change from baseline to aid in interpretation. Additionally, the same four participants (outliers who were removed in the process of normalizing the data) were excluded from these analyses, resulting in 42 participants' data available for most analyses. Fewer participants had DERS (n=17) and HRV (n=29) data. Participants' average MPSS score decreased by approximately 30%, from 28.3 to 19.2, $t(41) = 5.70$, $p < 0.000$, $d = 0.88$. The average square-root transformed BDI-II scores decreased by approximately 20%, from 4.92 to 3.89, $t(41) = 4.42$, $p < 0.000$, $d = 0.68$. The 42 participants' CSES showed a score increase of approximately 20% as well, from 141.7 to 171.8, $t(41) = -5.33$ $p < 0.000$, $d = -0.82$. The average reciprocal-root transformed MDI score decreased by 11%, from -0.13 to -0.15, $t(41) = 5.62$ $p < 0.000$, $d = -0.87$. Only seventeen participants had posttreatment DERS data included in this analysis. The average score of those seventeen decreased 6%, from 101.9 to 95.4. The effect was moderate, but not statistically significant, $t(16) = 1.65$, $p = 0.11$, $d = 0.40$. The average KIMS score increased by approximately 5%, from 122.8 to 129.2, $t(41) = -3.29$, $p = 0.002$, $d = -0.51$. The average MAIA score increased by slightly more 20%, from 95.4 to 115.8, $t(41) = -6.30$, $p < 0.000$, $d = -0.97$. Twenty-nine participants had HRV data included in this analysis. These participants' average HRV during the breath-focused blocks decreased by from 0.04 to -0.05, $t(28) = 0.72$, $p = 0.48$, $d = 0.13$. This effect size was small and not statistically significant.

Correlations between Clinical Variable Change Scores

Change scores for the clinical variables were computed by regressing posttreatment data onto pretreatment data and saving the studentized residuals as the change scores. After excluding the four participants as outlined above, 17 participants had change in DERS data, and 29 had change in HRV data, and 42 participants had change scores for the other self-report measures.

Change in HRV did not correlate significantly with any of the self-report measures (see Table 4). Change in MPSS significantly correlated strongly with change in BDI-II and moderately with change in MDI. These two correlations were in the expected directions. The change in CSES significantly correlated moderately with change in BDI-II and change in MAIA, and strongly with change in MDI. These significant correlations were in expected directions. Seventeen participants had change in DERS data; change in DERS significantly correlated change in both BDI-II score and MDI score. Those correlations were moderate and each in the expected direction. While the DERS and CSES did not correlate significantly, the DERS did significantly correlate with the subscales of the CSES: use problem-focused coping (UPFC), which had a strong, negative correlation that was statistically significant with the DERS; get support from family and friends (GSFF), which displayed a significant and moderately sized negative correlation with the DERS; and stop unpleasant emotions and thoughts (SUET), which evinced another moderately sized, significant negative correlation with the DERS. See Table 4 for full results.

Differences Between Treatment Groups

Statistical differences in pretreatment measures between augmented and non-augmented participants were examined used independent samples t-tests (see Table 5). Statistically significant differences emerged for the several measures. A large effect size was observed for the pretreatment DERS, $t(39) = -2.14$, $p=0.04$, $d=0.68$. The pretreatment CSES also evinced a statistically significant difference with a large effect size, $t(43) = 2.06$, $p<0.05$, $d=0.64$. Lastly, the pretreatment MAIA was similarly different: $t(44) = 2.34$, $p=0.02$, $d=0.69$. With the exception of the KIMS, the other self-report measures, while not statistically significant, showed moderate to large effect sizes. The effect size for the difference in KIMS was small ($d=0.10$), and the difference in HRV was minimal (*d*=0.01). These findings suggested that participants in the augmented group were significantly more symptomatic at the onset of treatment; as such, treatment group was entered as a covariate in all subsequent analyses. Table 5 contains more detailed results.

Main Analyses

Aim 1a – Coping Self-efficacy as a Mediator of Change in PTSD Symptoms

The first aim of this study was to investigate the role of coping self-efficacy as a mediator of change in both PTSD symptoms (Aim 1a) and emotion dysregulation (Aim 1b, below) after the BFMM intervention. I hypothesized that coping self-efficacy would significantly mediate the relationship between pre- and posttreatment PTSD symptoms after accounting for the effects of the two covariates, treatment group and amount of practice. Figure 5a displays the effects of pretreatment PTSD symptoms on posttreatment PTSD symptoms, mediated by change in coping self-efficacy. Both the average amount of practice (ordinal) and treatment condition (dichotomous) were entered as covariates. In the first step (path *c*) of the mediation model, the regression of pretreatment PTSD symptoms on posttreatment PTSD symptoms was significant, $b = 0.71$, $\beta = 0.50$, $t(41) = 3.46$, $p = 0.001$. The second step (path *a*) demonstrated that the regression of pretreatment PTSD symptoms on the mediator, change in coping self-efficacy, was not significant, $b = -0.03$, $\beta = -0.21$, $t(41) = -1.30$, $p = 0.20$. In the third step (path *b*), it was shown that the regression of change in coping self-efficacy on posttreatment PTSD symptoms was not significant, $b = -2.48$, $\beta = -0.21$, $t(40) = -1.51$, $p = 0.14$. The last step (path *c*') demonstrated that pretreatment PTSD symptoms was still a significant predictor of posttreatment PTSD symptoms, while controlling for change in coping self-efficacy, $b = 0.65$, $\beta = 0.45$, $t(40) = 3.15$, $p = 0.003$. Neither covariate (treatment group and amount of practice) accounted for a significant proportion of the variance at any step (*p*'s > 0.19). The effect size (P_M) was calculated as the ratio of the indirect effect to the total effect (Wen & Fan, 2015). It was found that change in coping self-efficacy did not mediate the relationship between pre- and posttreatment PTSD symptoms (a_1b_1 = 0.06, SE = 0.07, 95% CI = [-0.04, 0.22], P_M = 0.09). As a result, hypothesis 1a was not supported, as the change was non-significant and the partial mediation was small, as only 9% of the relationship operated indirectly.

Aim 1b – Coping Self-efficacy as a Mediator of Change in Emotion Dysregulation

Due to many participants not completing the posttreatment DERS, as well as the conceptual and statistical relationship between the DERS and MDI, the MDI was substituted for the DERS as a measure of emotion dysregulation. I hypothesized that change in coping self-efficacy would significantly mediate the relationship between pre- and posttreatment emotion dysregulation. The correlation between the measures was 0.41 at pretreatment and 0.60 at posttreatment, both of which were statistically significant. Moreover, as discussed in the background section, the measures overlap theoretically, as individuals in the subgroup experience dissociation in response to emotion dysregulation. Additionally, to help to control for extreme values, the MDI scores were transformed via a reciprocal root transformation. Figure 5b demonstrations the effects of pretreatment emotion dysregulation on posttreatment emotion dysregulation, mediated by change in coping self-efficacy.

In step one of the mediation model (path *c*), the regression of pretreatment dissociative symptoms on posttreatment dissociative symptoms, ignoring the mediator, was significant, b = 0.63, β = 0.59, $t(41)$ = 4.35, p< 0.000. The second step (path *a*) evinced that the regression of pretreatment dissociative symptoms on the mediator, change in coping self-efficacy, was not significant, b = 6.03, β = 0.10, $t(41)$ = 0.61, p = 0.54. In the third step (path *b*), it was shown that the regression of change in coping self-efficacy on posttreatment dissociative symptoms was significant after controlling for pretreatment dissociative symptoms, $b = -0.01$, $ß = -0.47$, $t(40) = -4.41$, $p < 0.000$. The fourth step (path *c'*) demonstrated that pretreatment dissociative symptoms was still a significant predictor of posttreatment dissociative symptoms, while controlling for change in coping self-efficacy, $b = 0.69$, $ß = 0.64$, $t(40) = 5.63$, $p < 0.000$. The covariates were not significant at any step (p's > 0.68). Change in coping self-efficacy did not significantly mediate the relationship between pretreatment and posttreatment dissociative symptom scores ($a_1b_1 = -0.05$, SE = 0.09, 95% CI = [-0.23, 0.12], $P_M = 0.08$). The proportion of mediation indicates that 8% of the effect occurs indirectly. In sum, hypothesis 1b was not supported, given then non-significant and weak partial mediation effect.

Aim 2 – Correlation Between Changes in HRV and Changes in Self-report Measures

The second aim of this study was the examination of the relationship between changes in HRV and changes in coping self-efficacy, emotion dysregulation, and post-traumatic symptomatology. It was hypothesized that changes in HRV would correlate positively with the change in coping self-efficacy (CSES) and negatively with changes in both emotion dysregulation (MDI in lieu of DERS) and PTSD symptoms (MPSS). Changes in HRV data did not correlate significantly with changes in any self-report measures (p's > 0.1; see Table 4 for full results). The strongest correlation was that of the MPSS and HRV ($r = -0.24$, $p = 0.20$), which was weak, as were those with the other self-report measures (r's < $|0.17|$). Thus, hypothesis 2 was not supported.

Aim 3 – Coping Self-efficacy as a Mediator of Change in HRV During Breath-focused Condition

For the third aim, I hypothesized that coping self-efficacy would significantly mediate the relationship between the averages of session one and session six HRV during the breath-focused condition. Figure 6a displays the effect of session one's average HRV (session one HRV) on session six's average HRV (session six HRV), mediated by change in coping self-efficacy.

Step one (path *c*) of the mediation model demonstrated that the regression of session one HRV on session six HRV, ignoring the mediator, was significant, $b = 0.38$, $\beta = 0.41$, $t(27) = 2.13$, $p = 0.04$. Step two (path *a*) showed that the regression of session one HRV on the mediator, change in coping self-efficacy, was not significant, $b = -0.02$, $\beta = -0.01$, $t(27) = -0.06$, $p = 0.95$. Step three (path *b*) established that the regression of change in coping self-efficacy on session six HRV was not significant when controlling for session one HRV, $b = -0.09$, $\beta = -0.17$, $t(26) = -0.94$, $p = 0.35$. The fourth step (path *c'*) confirmed that session one HRV was still a significant predictor of session six HRV when controlling for change in coping self-efficacy, $b = 0.38$, $\beta = 0.41$, $t(26) = 2.12$, $p = 0.04$. The covariates were not significant at any step (*p*'s >0.14). Change in coping self-efficacy was not a significant mediator of the relationship between session one and session six HRV ($a_1b_1 = -0.002$, SE = 0.06, 95% CI = [-0.11, 0.15], $P_M = 0.005$). Since the index of the indirect effect was non-significant, and the proportion of the effect accounted for by the indirect pathway was less than one percent (0.5%), hypothesis 3 was not supported.

Post hoc Analysis 3b

As HRV was collected as timeseries data, investigating where in the waveform change occurs (if any) in HRV will likely improve the nuance of the analysis of HRV data. To do so, t-tests were run at all points in the waveform to determine if there were intervals of time in which the breath-focused condition was statistically different than zero. Autocorrelations and multiple comparisons were controlled for in the following manner. The Buchwald-Guthrie (1991) style estimation of minimum window length was employed. Autocorrelations in HRV data were found to be very high (all > 0.99). This estimation resulted in a minimum length of approximately ten seconds (*i.e.* 10.59s with 35 participants and 9.5s with 40 participants), so that value was used to determine which findings were significant.

Participants with good-quality HRV data in both session 1 and session 6 were included in this analysis. The change in HRV for almost all of the first twelve seconds of the blocks was statistically greater than zero for session one (0.01s to 11.76s, $F(1,30) = 6.40$, $p = 0.02$) indicating that this peak was statistically significant and meaningful (Fig. 7a). When comparing the average of the breath-focused blocks to that of the rest blocks, this difference did not pass the minimum length required (0.01s to 8.26s: $F(1,30) = 5.98$, $p = 0.02$) (Fig. 7b).

Figure 6b displays the effect of session one HRV (measured by averaging HRV in the first fifteen seconds of each breath-focused condition block) on session six HRV, mediated by change in coping self-efficacy. In the first step (path *c*), the regression of session one HRV on session six HRV, ignoring the mediator, was significant, $b = 0.48$, $\beta = 0.50$, $t(27) = 2.87$, $p < 0.01$. In the second step (path *a*), the regression of session one HRV on change in coping self-efficacy, was not significant, $b = -0.11$, $\beta = -0.06$, $t(27) = -0.29$, $p = 0.78$. In the third step (path *b*), the regression of change in coping self-efficacy on session six HRV was not significant when controlling for session one HRV, $b = 0.05$, $\beta = 0.09$, $t(26) = 0.52$, $p = 0.61$. The fourth step (path *c'*) confirmed that session one HRV remained a significant predictor of session six HRV, after controlling for change in coping self-efficacy, $b = 0.49$, $\beta = 0.51$, $t(26) = 2.85$, $p < 0.01$. The covariates were not shown to be significant at any step (*p*'s > 0.43). Change in coping self-efficacy was not a significant mediator of the relationship between the first fifteen seconds of session one and session six HRV ($a_1b_1 = -0.004$, SE = 0.05, 95% CI = [-0.10, 0.11], $P_M = -0.01$).

The indirect effect accounted for approximately 1% of the relationship, which was not statistically significant. Therefore, this *post hoc* analysis of Aim 3 did not support the original aims hypothesis.

Exploratory Aim 4 – Pretreatment Emotion Dysregulation Moderating the Mediating Effect of Change in Coping Self-efficacy

This exploratory aim examined to what extent the indirect effect of pretreatment PTSD symptoms on posttreatment PTSD symptoms varies as a function of change in coping self-efficacy, where pretreatment emotion dysregulation was moderating the path from pretreatment PTSD symptoms to change in coping self-efficacy. It was hypothesized that pretreatment emotion dysregulation (DERS) would moderate the indirect effect of change in coping self-efficacy (CSES) on the relationship between pre- and posttreatment PTSD symptoms, with those demonstrating less emotion dysregulation evincing larger indirect effects. Figure 8 shows these effects.

Emotion dysregulation, pretreatment PTSD symptoms, and their interaction were all regressed on change in coping self-efficacy. In the next step (path *a*) the regression of pretreatment PTSD symptoms on change in coping self-efficacy was not significant ($b = 0.12$, $t(5,34) = 1.46$, $p = 0.15$). The interaction term (path *d*), was not found to be significant ($b = -0.001$, $t(5,34) = -1.63$, $p = 0.11$). The test of highest order unconditional interaction also indicated that pretreatment emotion dysregulation did not significantly moderate the relationship between pretreatment PTSD symptoms and change in coping self-efficacy, $R^2\Delta = 0.06$, $F(1, 34) = 2.69$, $p = 0.11$. Next (path *b*), when controlling for the effects of pretreatment PTSD symptoms, the effects of change in coping self-efficacy on posttreatment PTSD symptoms was not significant ($b = -2.74$, $t(4,35) = -1.57$, $p = 0.13$). In the final step (path *c'*), when controlling for the effects of change in coping self-efficacy on posttreatment PTSD symptoms, the regression of pretreatment PTSD symptoms on posttreatment symptoms was significant (b = 0.58, t(4,35) = 2.50, p < 0.02). Using Hayes's (2013) conventional "pick-a-point" approach, the conditional indirect effects of the moderator (pretreatment emotion dysregulation) at its 16^{th}, 50^{th} and 84^{th} percentile, were examined. None of the conditional three indirect effects were significant (*IE* = -0.12, bootstrapped 95% CI: [-0.60, .10]; *IE* = -0.04, bootstrapped 95% CI: [-0.31, 0.12]; *IE* = 0.08, bootstrapped 95% CI: [-0.04, 0.35]). These findings suggest that moderated mediation did not occurred in this model. Indeed, the index of moderated mediation was also not significant (*IMM* = 0.003, SE = 0.004, bootstrapped 95% CI = [-0.001, 0.01]). Consequently, hypothesis 4 was not supported.

Post hoc exploration Aim 2 – correlations with HRV timeseries data

In order to explore the relationship between coping self-efficacy and HRV more fully, a procedure similar to that in Aim 3b was employed to examine the correlation between coping self-efficacy and timeseries HRV data. Just as before, the Buchwald-Guthrie (1991) style estimation of minimum section length was set to be ten seconds. In this analysis, correlations with coping self-efficacy score at each timepoint were completed and graphed for a) pretreatment CSES score and average session 1 HRV during breath-focused condition; b) posttreatment CSES score and average session 6 HRV during breath-focused condition; and c) change in CSES score and average session 6 HRV during breath-focused condition (see Fig. 9). No statistically significant relationships were borne out with this approach.

Post hoc analysis of treatment effect

Because of the active treatment arm of this study, the effects of the physiological augmentation were explored by means of independent samples t-tests. Group differences were not found to be statistically significant different for posttreatment MPSS ($t(44) = -0.55$, $p = 0.58$, $d = 0.17$), CSES ($t(43) = 1.56$, $p = 0.13$, $d = 0.47$) or average HRV both over the whole block ($t(29) = -0.94$, $p = 0.36$, $d = 0.36$) and over the first fifteen seconds ($t(29) = -0.69$, $p = 0.50$, $d = 0.27$). Despite not being statistically significant, the between-group difference on posttreatment was moderate for CSES and small for both metrics of average HRV. T-tests with change scores for those measures were also non-significant (MPSS: $t(44) = 0.08$, $p = 0.94$, $d = 0.02$; CSES: $t(43) = -0.10$, $p = 0.92$, $d = 0.03$; HRV: $t(29) = -0.97$, $p = 0.34$, $d = 0.37$; 15s HRV: $t(29) = -0.65$, $p = 0.52$, $d = 0.24$). While none of the differences were statistically significant, the between-group difference in change in average HRV was small for both metrics. The augmented (*i.e.* active) treatment group had lower posttreatment CSES scores and also displayed both a higher average HRV and bigger change in average HRV when compared against the participants who received the non-augmented treatment.

Post hoc analysis of the effects of over-/under-modulation

To examine whether or not over-/under-modulators had any group-based characteristics that might predict change in self-report scores of interest (MPSS, CSES, and MDI), a visual inspection of the potential non-linear relationship was first examined visually using scatterplots of the average of the first 15s of session one HRV and the change in those three variables. The quadratic relationships were investigated by means of scatterplot fit lines and returned no significant findings: R^2's = 0.13, 0.02, and 0.005, respectively (Figure 10). The quadratic fit lines were only greater than linear counterparts by insignificant margins, as the R^2's increased by between 0.003 and 0.015.

Post hoc analysis of characteristics associated with changes in coping self-efficacy

In order to examine who may have evinced larger changes in coping self-efficacy, correlations were completed to see the relationships between change in coping self-efficacy and pretreatment clinical measures. A weak, negative correlation emerged between change in CSES score and pretreatment DERS scores ($R^2 = -0.33$, $p = 0.04$). Upon further examination via non-linear regression (pretreatment DERS scores onto change in CSES), the relationship was best fit by a quadratic (u-shaped) function ($R^2 = 0.215$), but the pretreatment DERS was not a significant predictor of change in coping self-efficacy ($b = 0.09$, $ß = 2.16$, $t(2,37) = 1.94$, $p = 0.06$). See Figure 11.

Discussion

Overview

It has been established that a subgroup of patients with PTSD experience high levels of emotion dysregulation (Cloitre, Courtois, et al., 2012; Ehring & Quack, 2010; Foa & Hearst-Ikeda, 1996). This subpopulation is characterized by chronic trauma exposure (Cloitre et al., 2002; Cole et al., 1994) and low levels of self-efficacy (Linehan et al., 1991; Saigh et al., 1995). Self-efficacy plays a role in maintenance of PTSD symptoms (Cloitre et al., 2014; Nygaard et al., 2017; Resick et al., 2007). Strong evidence supports the use of mindfulness interventions for populations with trauma histories, as these treatments improve PTSD symptoms (King et al., 2013; Polusny et al., 2015). Mindfulness also enhances self-efficacy, particularly in populations with emotion dysregulation (Chang et al., 2004), and has even been incorporated into treatments for individuals with PTSD and high levels of emotion dysregulation (Cloitre et al., 2002; Harned et al., 2012). Lastly, self-efficacy has been shown to mediate treatment effects in substance disorder populations (Borrelli & Mermelstein, 1994; T. G. Brown et al., 2002), and has evinced mixed support for in populations with non-suicidal self-injury (Heath et al., 2016; Midkiff et al., 2018). For these reasons, I sought to examine the role of self-efficacy in mediating the effects of a brief mindfulness intervention for individuals with PTSD and high levels of emotion dysregulation.

Interpretations

Participants demonstrated significant reductions in PTSD symptoms, depressive symptoms, and symptoms of dissociation following mindfulness treatment. They also demonstrated improvements in mindfulness, self-efficacy, and interoceptive awareness. Participants, did not, however, demonstrate significant change in average HRV or self-reported emotion regulation, despite the reduction of the latter being a moderate effect size. Furthermore, significant between-group differences existed for the two treatment conditions – with the active (augmented) treatment group evincing worse symptomatology at baseline on the majority of the measures. Treatment group was subsequently controlled for as a covariate in the analyses.

The study aims and hypothesized effects of self-reported self-efficacy examined were not well supported by the data. At most, self-efficacy had a very small partial mediation effect for change in PTSD symptoms and change in dissociation symptoms, but these effects were not statistically significant. Heart rate variability, which has been shown to be a psychophysiological proxy for emotion regulation, also failed to meaningfully correlate with self-reported measures of symptomatology. Given the robust finding that HRV typically correlates both with PTSD symptoms – see Hinrichs *et al*. (2017), for findings in this population – and with self-efficacy (Haney & Long, 1995; Schwerdtfeger et al., 2008) this result was unexpected. This finding suggests that either something was quite different about this population (or more specifically, their HRV) even when compared with similar populations with histories of trauma that exhibit emotion dysregulation and dissociative symptoms, or methodological limitations obfuscated the effects (see discussion of limitations). This population is unique in that this is the first study of this physiologically augmented BFMM. This population was also comprised of both treatment seeking and non-treatment seeking participants, while most of the relevant extant studies recruit just one of those populations. Furthermore, self-efficacy did not mediate the relationship between HRV during the breath-focused condition at the first session with that at the sixth session, even when focusing in on the timeframe in which the mindfulness meditation intervention demonstrated differences between conditions.

Overall, participants did experience an increase in self-reported coping self-efficacy after completing a brief, computer-based BFMM intervention. Importantly, changes in coping self-efficacy significantly correlated with improvements in interoceptive awareness and dissociative symptoms – the primary target of this intervention. In other words, participants who rated their self-efficacy higher also rated their ability to monitor bodily states and cues higher while also reporting less frequent and/or intense dissociative experiences. While significant differences did exist in baseline symptomatology between treatment groups, change in coping self-efficacy was similar between participants who received the augmented treatment and those who received treatment as usual. Pretreatment emotion dysregulation (DERS) was the only variable found to have correlated with change in self-efficacy. The relationship emerged as curvilinear, suggesting a more complex relationship between pretreatment levels of emotion dysregulation (DERS) and change in coping self-efficacy. This effect was also found in the moderated mediation model (Aim 4). At low levels of pretreatment emotion dysregulation, the relationship between PTSD and change in self-efficacy was negative. However, at high levels of the moderator, the same relationship was positive. In other words, participants who reported having a diminished ability to manage their emotional distress reported lower changes in self-efficacy with more PTSD symptoms. On the other hand, the women in the study who rated their capacity for emotion regulation highly demonstrated higher changes in self-efficacy with more PTSD symptoms. This finding aligns with the theoretical underpinnings of self-efficacy in emotion regulation: "whether or not you think you can, you are probably right." The high levels of distress from both increased trauma-related symptoms and emotion dysregulation more generally could very well have forced these participants to engage in the maladaptive emotion regulation strategies outlined above, which decrease one's confidence in managing distress. On the other hand, for participants with low baseline emotion dysregulation, even experiencing high levels of PTSD symptoms was not seen as insurmountable distress. This trend aligns with the study's foundational premise suggesting that changes in self-efficacy may likely mediate changes in other symptoms. Clinically, these findings support the extent literature on providing patients with high levels of emotion dysregulation some skills to tolerate the emotions better to assist with reduction in trauma symptoms (e.g. Ford et al., 2005; Harned et al., 2012; Kimbrough et al., 2010).

Limitations

The small sample size of this study resulted in inadequate statistical power for the mediation analyses (Aims 1, 3, and 4), which bootstrapping attempted to help to redress. Furthermore, the lack of complete data (due to technical issues, quality concerns, and participant dropout) exacerbated the already small sample size. The target recruitment determined via *a priori* power analysis was not reached, and likely an underestimation of the required sample size for several reasons: the analysis did not account for the multiple regression models required for a single mediation model, let alone multiple regression models. Additionally, given the differences between the treatment groups, more variables were entered into the analyses than originally anticipated. And given the small sample size, entering a full complement of theoretical covariates would have been costly in terms of statistical power. Furthermore, this study operated under the assumption that change in coping self-efficacy would be a mechanism of symptom reduction, and other directions of change were also not investigated.

While most of analyses returned no evidence of relationships as hypothesized, some returned moderate, and even strong, effect sizes that were clearly meaningful but not found to be statistically significant. These effects certainly need to be interpreted with caution given their lack of statistical significance and the multiple comparisons performed with the data. However, several of these effect sizes are large enough to suggest that some null hypotheses may have incorrectly been accepted.

Limits from the use of the Coping Self-efficacy Scale in this population also merit noting. The normative sample for the CSES was predominately white, college-educated HIV-seropositive men. Given the distinct demographic differences of this sample demographic compared to the normative sample, it is uncertain whether or no the CSES is a valid assessment of coping self-efficacy in this study's population. Coping with stress and treatment is also significantly different for this population. African-American women endorse spirituality and religious activities as coping strategies significantly more than Caucasian counterparts (El-Khoury et al., 2004), and may even be a moderator of healthier coping after traumatic events (Staton-Tindall, Duvall, Stevens-Watkins, & Oser, 2013). The CSES does not substantially account for those coping behaviors. Two main sources of self-efficacy are personal experiences and models (Bandura, 1994). This population typically has experienced trauma at an early age, survived several events – often witnessing or experiencing chronic abuse (Greason & Cashwell, 2009) – and may be predisposed to trauma by means of intergenerational factors (Powers et al., 2020). These occurrences persist above and beyond the obstacles and stressors that this population contends with (see Davis, Ressler, Schwartz, Stephens, & Bradley, 2008).

Other potential limitations are worth considering due to the nature of how this dissertation's participants were recruited. The intervention study utilized a large proportion of participants from a larger parent study. The parent study recruits participants from general medical care clinics, and as a result, many of whom are not explicitly treatment-seeking and agreed to enroll in the treatment study when recruited. However, in order to bolster study recruitment, this project opened its recruitment to include participants from the community directly interested in enrollment in the treatment study. Lastly, given the largely homogeneous sample studied, the results need to be generalized with caution.

Conclusion

In conclusion, this study failed to find statistically significant and meaningful results for the role of self-efficacy as potential mediator for a breath-focused mindfulness meditation intervention. Some interesting results emerged that align with the theoretical relationships between emotion dysregulation (largely) and self-efficacy, but this study was too underpowered to meaningful explore those relationships if they do indeed exist. The study does underscore the apparent complexity of the dynamics between emotion dysregulation, PTSD symptoms, and self-efficacy, particularly in a population who experience high levels of distress and significant life stressors. In sum, self-efficacy, being a complex multifaceted factor that overlaps with related self-regulatory capabilities, may not have been wholly accounted for, either theoretically or through measurement, accurately in this study.

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Appendix

Table 1

Clinical and demographic characteristics of analyzed sample

Demographics	**Analyzed Sample** (*n*=46)	
Age: *mean* (*SD*)	43.9 (12.6)	
Race: *n* (%) Black/AA	41 (89.1%)	
Education: *n* (%) some secondary education or more	26 (56.5%)	
Employment: *n* (%) employed	16 (34.8%)	
Arm of intervention: *n* (%) augmented	27 (58.7%)	
Average weekly practice	1.13 (0.83)	
Pretreatment Clinical Measures	**-----**	**After outlier removal**
MPSS	28.3 (8.14)	--
square-root transformed BDI-II	4.92 (1.15)	--
approximate untransformed BDI-II	24 (2.3)	--
CSES	137.4 (57.4)	141.7 (55.2) [*n*=45]
reciprocal-root transformed MDI	-0.13 (0.02)	--
approximate untransformed MDI	58 (15)	--
DERS	101.9 (26.9)	--
KIMS	119.5 (19.7)	122.8 (16.2) [*n* = 43]
MAIA	92 (24.6)	95.1 (23.0) [*n* = 45]
Average HRV during breath-focused block	0.04 (0.60)	--

Note. The *n*=46 unless otherwise noted to indicate exclusions made to normalize data distributions. Weekly practice was measured ordinally, where 0 equaling no practice, 1 equaling <20 minutes that week, 2 equaling 20-50min. that week, and 3 equaling >50 minutes that week.

Table 2

Associations between clinical assessments and HRV at pretreatment

	MPSS	BDI-II	CSES	MDI	DERS	KIMS	MAIA
MPSS	--						
BDI-II	0.52***	--					
CSES	-0.58***	-0.68***	--				
MDI	0.46**	0.45**	-0.37*	--			
DERS	0.48** *n=38*	0.64*** *n=38*	-0.63*** *n=38*	0.41** *n=38*	--		
KIMS	0.28	0.30	-0.11	0.40**	0.37* *n=38*	--	
MAIA	-0.09	-0.30	0.50***	-0.18	-0.28 *n=38*	0.36*	--
HRV	-0.01 *n=29*	0.18 *n=29*	0.02 *n=29*	0.11 *n=29*	0.23 *n=26*	-0.24 *n=29*	-0.03 *n=29*

Note. The *n*=42 unless otherwise indicated. BDI scores were square-root transformed and MDI scores were reciprocal-root transformed. *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

Table 3

Associations between clinical assessments and HRV at posttreatment

	MPSS	BDI-II	CSES	MDI	DERS	KIMS	MAIA
MPSS	--						
BDI-II	0.68***	--					
CSES	-0.40**	-0.51***	--				
MDI	0.56***	0.65***	0.40**	--			
DERS	0.50* *n=17*	0.67** *n=17*	-0.67** *n=17*	0.60* *n=17*	--		
KIMS	0.37*	0.18	0.18	0.15	0.09 *n=17*	--	
MAIA	-0.25	-0.39*	0.64***	-0.29	-0.38 *n=17*	0.45**	--
HRV	-0.04 *n=29*	0.19 *n=29*	0.01 *n=29*	0.18 *n=29*	0.13 *n=8*	0.03 *n=29*	0.05 *n=29*

Note. N=42 unless otherwise indicated. BDI scores were square-root transformed and MDI scores were reciprocal-root transformed. *: p<0.05, **: p<0.01, ***: p<0.001

Table 4

Associations between changes in clinical assessments and change in HRV

	MPSS	BDI-II	CSES	MDI	DERS	KIMS	MAIA	HRV	CSES UPFC	CSES GSFF
MPSS	--									
BDI-II	0.62***	--								
CSES	-0.30	-0.59***	--							
MDI	0.49***	0.59***	-0.62**	--						
DERS	0.47 *n=17*	0.57* *n=17*	-0.45 *n=17*	0.50* *n=17*	--					
KIMS	0.25	-0.03	0.19	-0.09	-0.01 *n=17*	--				
MAIA	-0.29**	-0.50***	0.48**	-0.46**	-0.40 *n=17*	0.41***	--			
HRV	-0.24 *n=29*	0.11 *n=29*	-0.14 *n=29*	0.05 *n=29*	0.17 *n=8*	-0.06 *n=29*	-0.01 *n=29*	--		
CSES UPFC	-0.20	-0.45**	0.56***	-0.48**	-0.80** *n*=17	0.25	0.50**	-0.50 *n*=29	--	
CSES GSFF	-0.03	-0.09	0.12	-0.02	-0.61* *n*=17	0.29	0.26	-0.41* *n*=29	0.33*	--
CSES SUET	-0.27	-0.42*	0.80***	-0.55***	-0.60* *n*=17	0.17	0.32	0.01 *n*=29	0.66***	0.22

Note. N=42 unless otherwise indicated. The change scores herein are studentized residuals. CSES subscales are the following: use problem-focused coping (UPFC); get support from family and friends (GSFF); and stop unpleasant emotions and thoughts (SUET). *: p<0.05; **: p<0.01; ***: p<0.001

Table 5

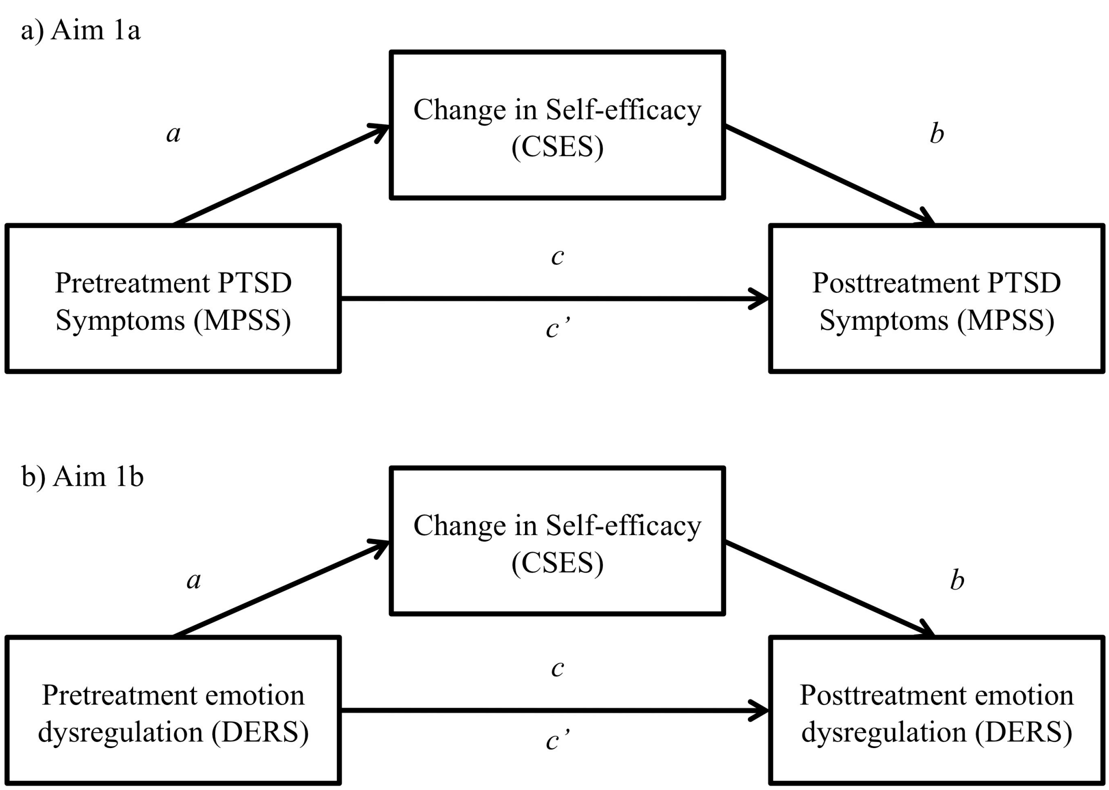
T-tests examining differences between treatment groups in pretreatment clinical measures

Measure *mean* (*SD*)	**Augmented participants**	**Non-augmented participants**	**Effect size** *d*, significance (*)
MPSS	26.0 (7.37)	29.4 (9.12)	0.41
square-root transformed BDI-II	4.75 (0.87)	5.04 (1.35)	0.26
approximate untransformed BDI-II	22.5 (9.08)	25.4 (15.4)	--
CSES	159.3 (44.2)	126.4 (58.2)	0.64*
reciprocal-root transformed MDI	-0.14 (0.02)	-0.13 (0.02)	0.51
approximate untransformed MDI	52 (14)	60 (18)	--
DERS	78.1 (25.0)	95.1 (25.2)	0.68*
KIMS	123.4 (12.9)	121.8 (18.2)	0.10
MAIA	101.6 (24.7)	85.2 (22.5)	0.69*
Average HRV during breath-focused block	0.04 (0.68)	0.03 (0.54)	0.01

Note. N=42 unless otherwise indicated. *: p<0.05; **: p<0.01; ***: p<0.001

Figure 1

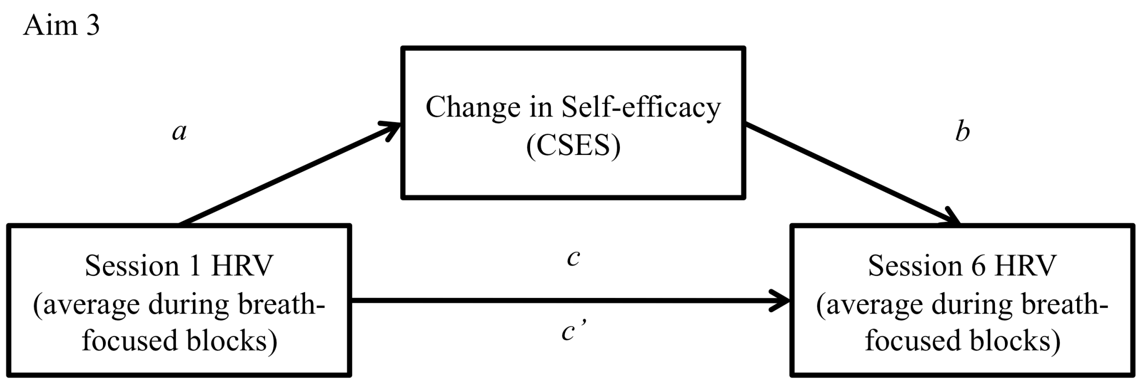
Model for mediation analyses for Aims 1a and 1b



Note. The models examine the role of change in self-efficacy as a mediator of change in both PTSD symptoms (Aim 1a) and change in emotion dysregulation (Aim 1b)

Figure 2

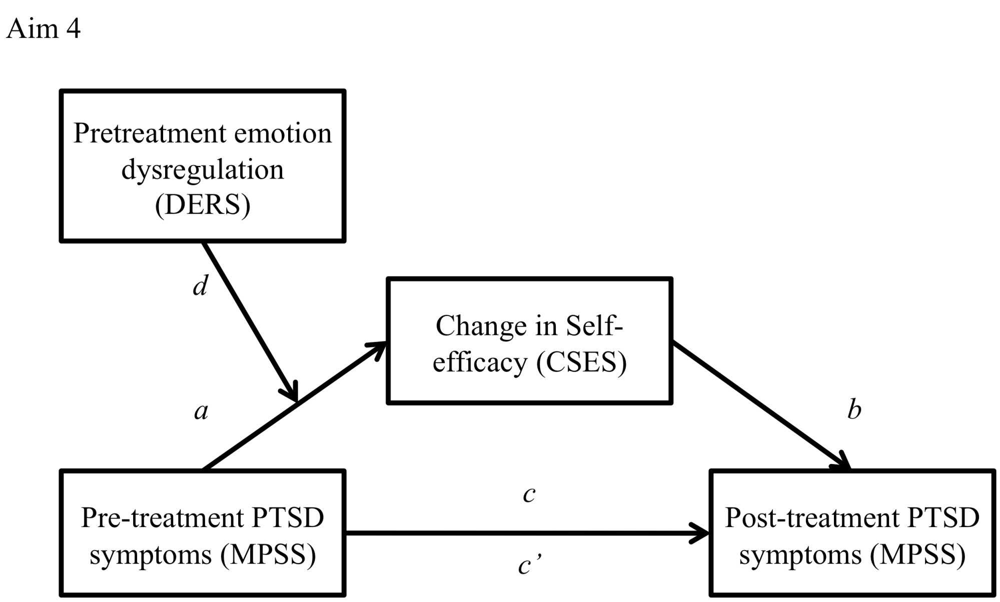
Mediation model for Aim 3



Note. The model examines the role of change in self-efficacy as a mediator of change average HRV during breath-focused block (Aim 3).

Figure 3

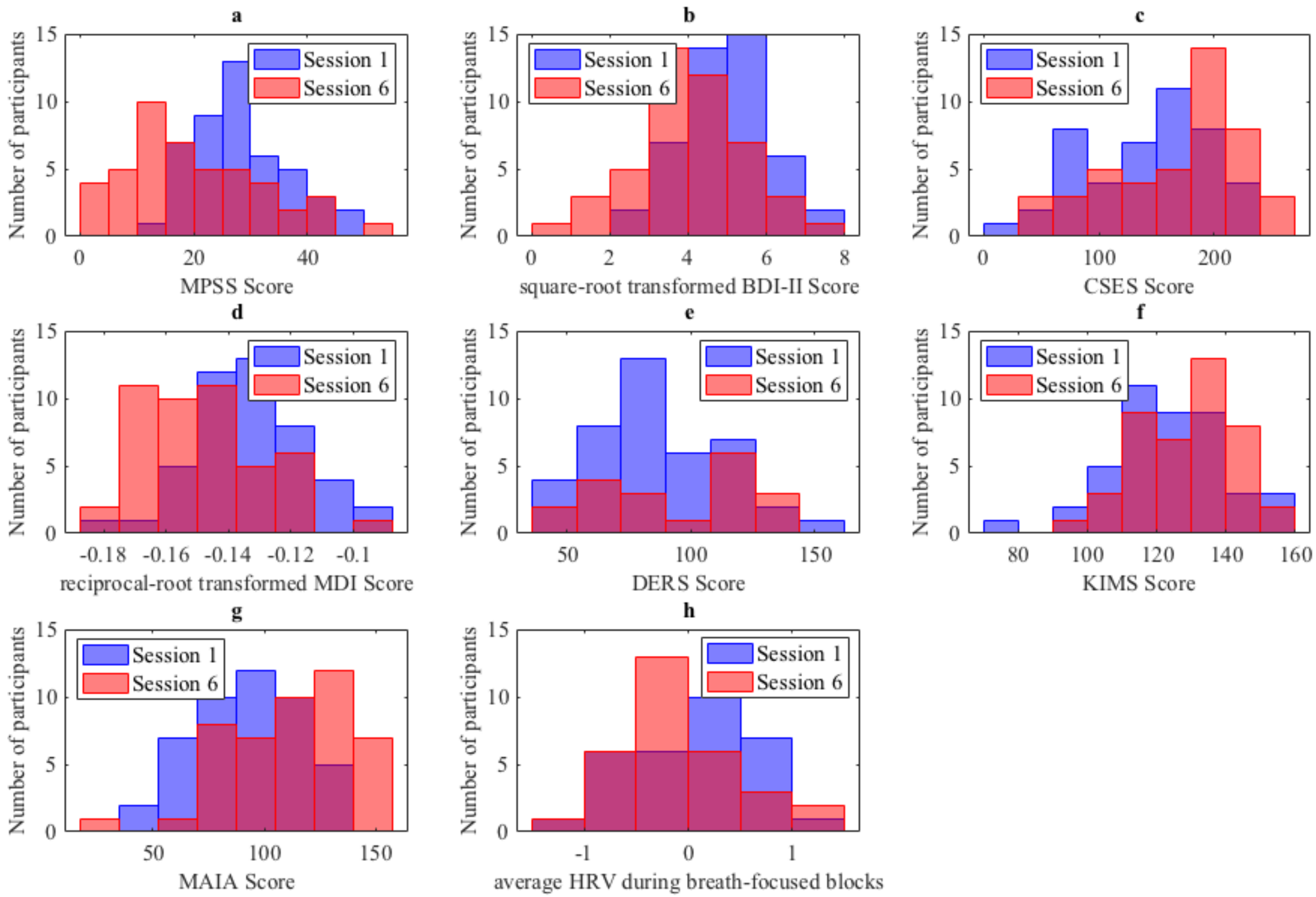
Moderated mediation model for Exploratory Aim 4



Note. The models examine the role of pretreatment emotion dysregulation as a moderator of the mediating role of change in self-efficacy on change in PTSD symptoms over treatment.

Figure 4

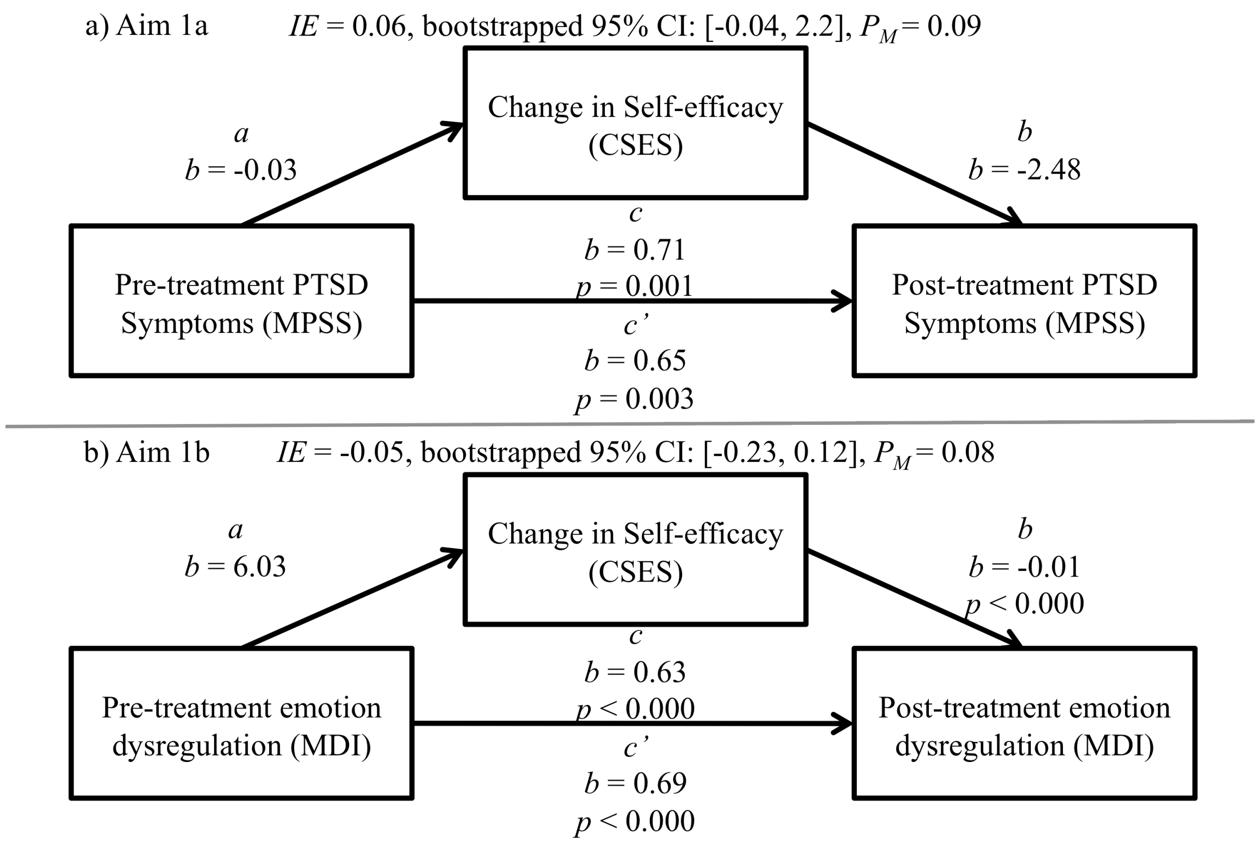
Histograms for pre- and posttreatment data



Note. Histograms of pre- and posttreatment data for a) MPSS; b) BDI-II; c) CSES; d) log-transformed MDI; e) DERS; f) log-transformed KIMS; g) log-transformed MAIA; and h) average HRV during breath-focused blocks

Figure 5

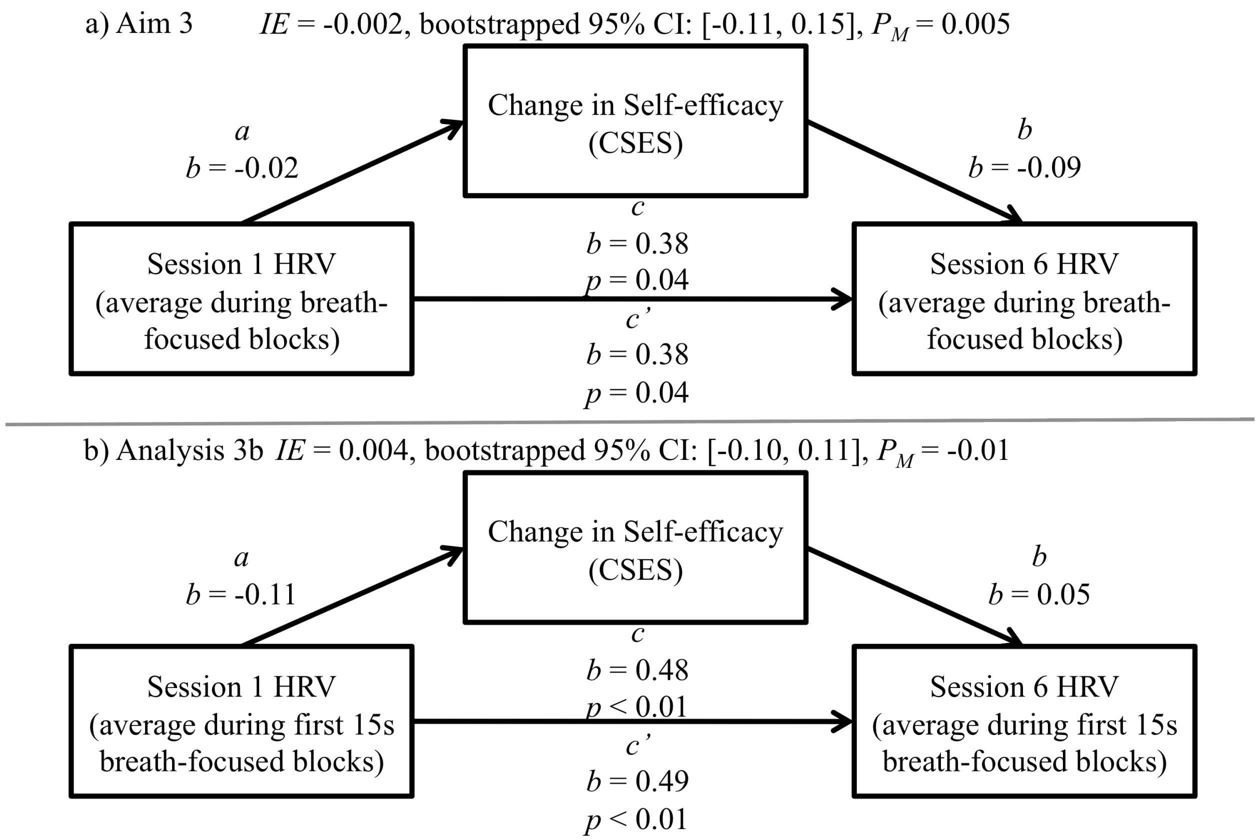
Aim 1a & 1b models



Note. Results from mediation analyses for Aim 1 completed with PROCESS Macro, with regression coefficients (*b*), p-values of statistically significant effects (*p*), as well as the indirect effects (IE) with bootstrapped (10000 samples) 95% confidence intervals [#, #], and proportion of relationship that operates indirectly (P_M)

Figure 6

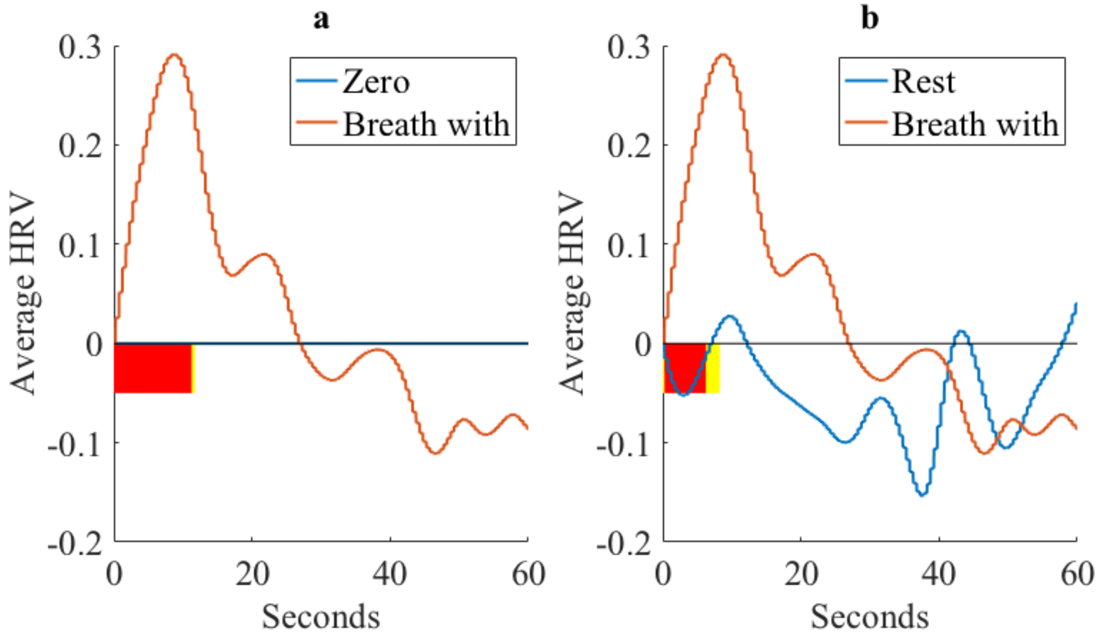
Aim 3 and post hoc analysis 3b models



Note. Results from mediation analyses for Aim 3a (average HRV during breath-focused blocks) and analysis 3b (average HRV during only the first 15s of breath-focused blocks) completed with PROCESS Macro, with regression coefficients (*b*), p-values of statistically significant effects (*p*), as well as the indirect effects (IE) with bootstrapped (10000 samples) 95% confidence intervals [#, #], and proportion of relationship that operates indirectly (P_M)

Figure 7

Differences in HRV waveforms of session one data

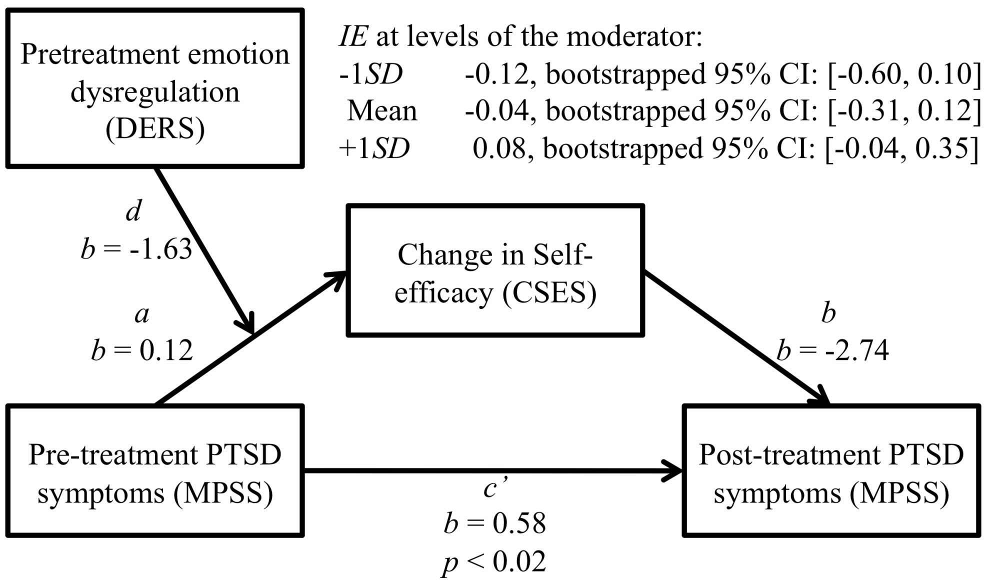


Note. Waveforms of average session one HRV during breath-focused blocks with statistically significant differences (red) and differences approaching significance (yellow) indicated, for a) breath-focused condition vs. zero; and b) breath-focused vs. rest condition blocks

Figure 8

Aim 4 models

Aim 4 *IMM* = 0.003, bootstrapped 95% CI: [-0.001, 0.01]

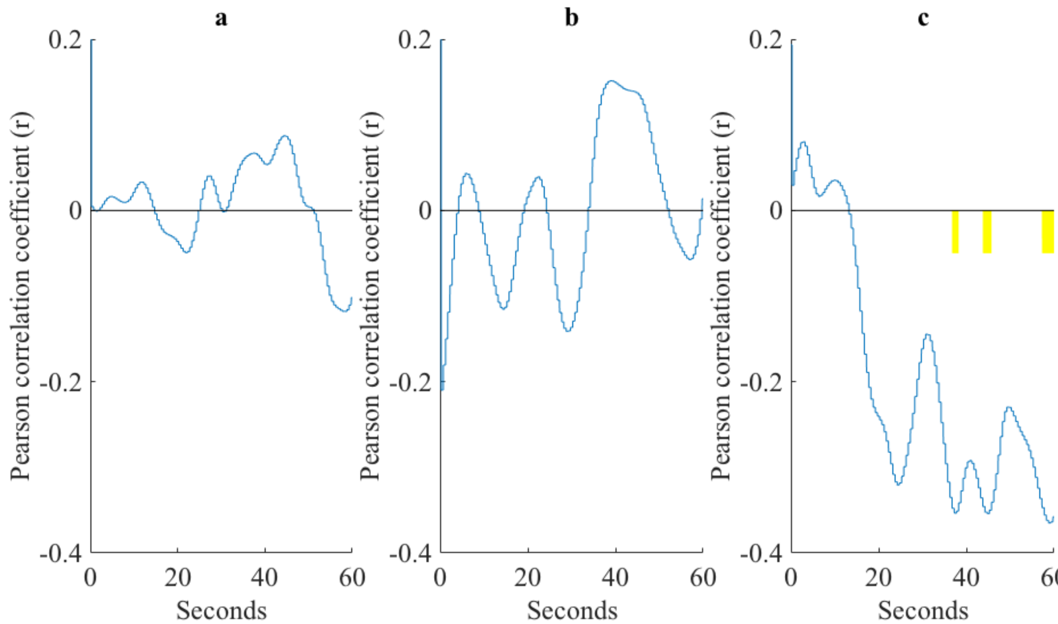


Model of highest order unconditional interaction: $R^2\Delta = 0.06$, $F(1,34) = 2.69$, $p = 0.11$.

Note. Results from moderated mediation analyses for Aim completed with PROCESS Macro, with regression coefficients (b), p-values of statistically significant effects (p), and the index of moderated mediation (IMM) with bootstrapped (10000 samples) 95% confidence intervals [#, #], in addition to the indirect effects (IE) at three levels of the moderator (mean & +/-1*SD*) with bootstrapped (10000 samples) 95% confidence intervals [#, #].

Figure 9

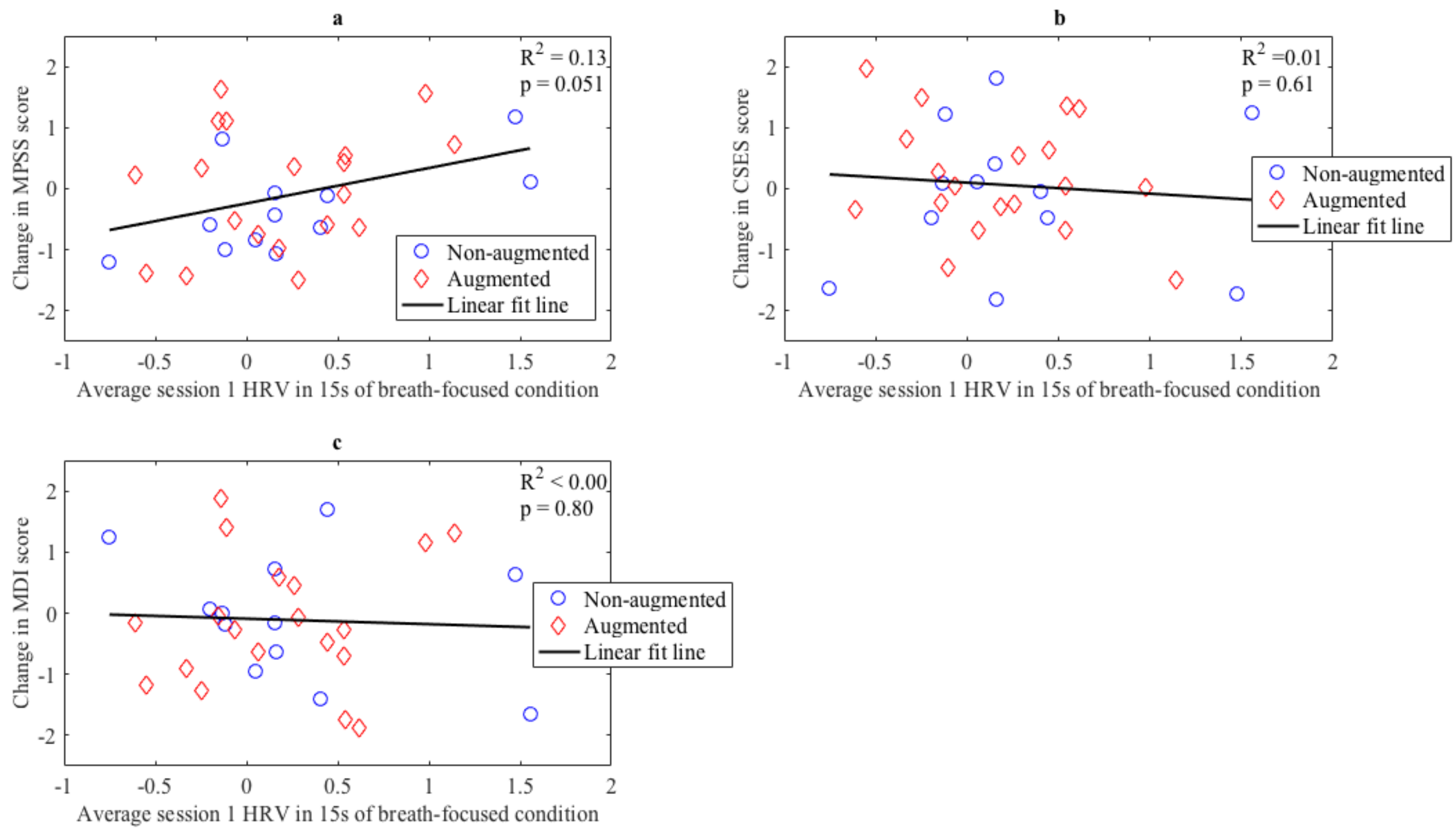
Timeseries correlations between CSES and average HRV during breath-focused blocks



Note. Waveforms of correlations between average session one HRV during breath-focused blocks and CSES scores with statistically significant differences (red) and differences approaching significance (yellow) indicated, for a) session one HRV and pretreatment CSES; and b) session six HRV and posttreatment CSES; and c) session six HRV with change in CSES score.

Figure 10

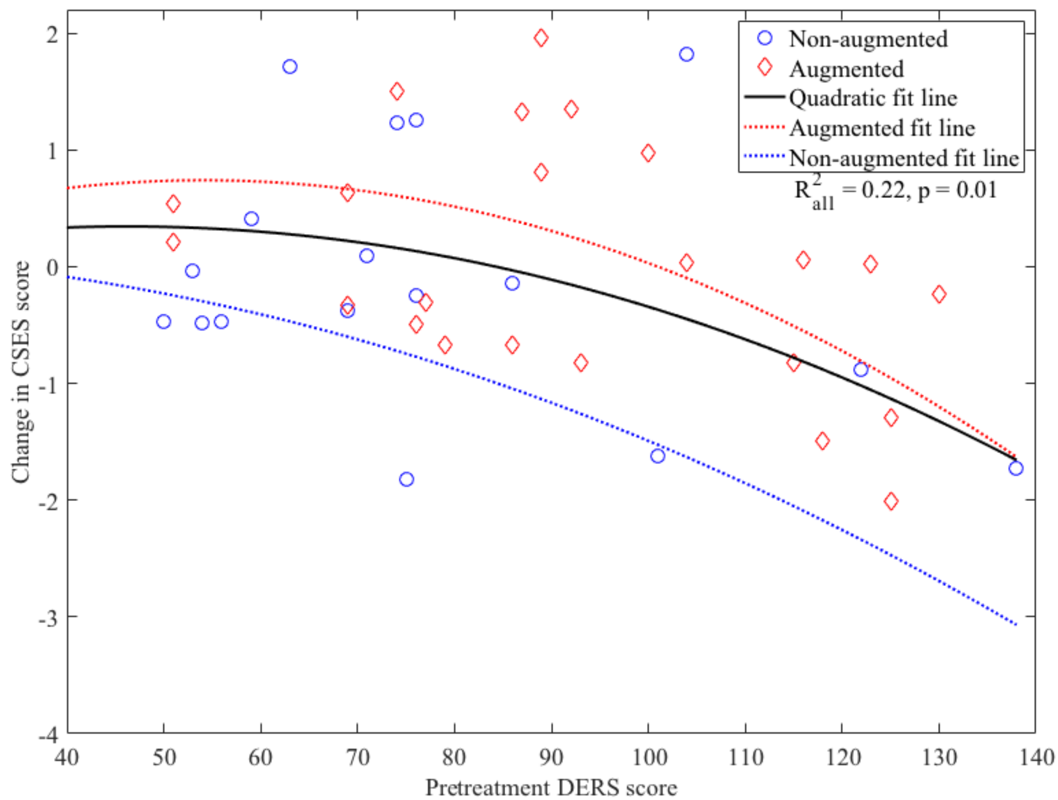
Correlations between pretreatment HRV and change in primary clinical measures



Note. Scatterplots of average session one HRV during the first 15s of the breath-focused blocks with change in a) MPSS score; b) CSES score; and c) MDI score. Data is marked by treatment condition (augmented vs. non-augmented); linear fit line also plotted.

Figure 11

Correlations between pretreatment HRV and change in primary clinical measures



Note. Scatterplot of change in CSES score with change in pretreatment DERS score. Data is marked by treatment condition (augmented vs. non-augmented); quadratic fit line also plotted.