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An abstract of

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Abstract

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Emotion regulation is the capacity to express, modulate, and respond to emotions appropriately based on ever changing internal and external environments. Increased emotion regulation has been correlated with greater well-being and mental health, while emotion dysregulation has been associated with multiple psychopathologies such as borderline personality disorder, depression, anxiety, and PTSD. Emotion regulation is also known to have physiological correlates such as Heart Rate Variability (HRV) which reflects autonomic nervous system activity. Greater autonomic regulation, reflected by higher HRV, has been associated with resilience to psychopathologies and increased emotion regulation, whereas reduced HRV has been linked to emotion dysregulation and a range of physical and psychological disorders such as cardiovascular disease, hypertension, depression, and PTSD. Minority populations, due to increased stressors and disease prevalence resulting from structural and cultural discrimination, would be expected to display relatively lower HRV than non-marginalized groups. Unexpectedly, a recent systematic review of HRV patterns across racial groups showed that Black populations displayed higher HRV than white populations. Researchers attributed this to a possibility of heightened emotion regulation in minority populations. The current study attempts to explore the relationship between difficulties in emotion regulation and HRV in a sample of trauma exposed Black Women at rest and during an emotion regulatory mindfulness task. Results showed that greater difficulties in emotion regulation were linked to lower HRV at rest, however greater

difficulties in emotion regulation were linked to higher HRV during an emotion regulatory mindfulness task. It was posited that this result may be due to HRV being an index of *effortful* use of emotional regulation resources and increased engagement of autonomic systems during an emotion regulation task. Discrimination may also be seen as emotion regulation events and therefore this pattern of high HRV during an emotion regulation task may translate to experiences of minority populations. Overall, the results call on the need for cultural and contextual sensitivity when interpreting physiological measures such as HRV, especially across racial and cultural groups.

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I. Introduction

A. Emotion Regulation

a. Definitions of Emotion Regulation

Emotion regulation has been defined as the capacity to express, modulate, and respond to emotions appropriately based on ever changing internal and external environments, is an adaptive mechanism that preserves social, physiological, and physical health (Gross, 2008; Song et al., 2014). It characterizes the ability to express types of emotions, flexibility between them, and the intensity of their expression. From an evolutionary perspective, emotions elicit psychophysiological states that aid with survival, for example, fear → fight or flight when encountering a dangerous animal (Cosmides & Tooby, 2000). When a situation evokes multiple emotional responses; individuals tend to base their responses on their goals or motivations. Over time, the situations in which people find themselves have also evolved and emotional responses continue to aid in social, cultural, and contextual adaptation to the continually changing environments and expectations (Aldao et al., 2013). Utilization of emotion regulation strategies have been linked to greater well-being and financial success (Kraiss et al., 2020; Côté et al., 2014). Emotion regulation abilities have also been associated with better job performance, leadership skills, and social tendencies such as interpersonal sensitivity and prosocial behavior (Torrence & Connelly, 2019; Côté & Miners, 2006; Lopes et al., 2005).

b. Emotion Dysregulation as a Feature of Psychopathology

Emotion regulation is a multidimensional construct that encompasses several components: 1) awareness and understanding of emotions, 2) acceptance of emotions, 3) control of impulsive behavior and ability to behave according to desired goals while experiencing negative emotions, and 4) use of appropriate emotion regulation strategies in response to individual goals and situational demands (Kraiss et al., 2020; Gratz & Roemer, 2004). Dysfunction in any of these dimensions has been described as **emotion dysregulation**.

Emotion dysregulation has been associated with multiple psychopathologies including borderline personality disorder, schizophrenia, depression, anxiety disorders, substance use disorders, and eating disorders (Burking & Wupperman, 2012; Appelhans & Luecken, 2006). Because disturbances in emotional processing and responding are a common feature of multiple types of psychopathologies, difficulties in emotion regulation have been posited as a transdiagnostic factor of mental health disorders and a target of numerous treatment approaches (Gross, 2014; Kring & Bachorowski, 1999). Dysregulation is related to maladaptive coping styles and negative affect, both of which increase risk of developing some mental health disorders and symptoms, including borderline personality disorder and posttraumatic stress disorder (PTSD; Bradley et al., 2015; Tull et al., 2015; Aldao et al., 2010).

c. Emotion Dysregulation in Trauma Exposed Populations

Emotion dysregulation is common among survivors of traumatic events (Badour & Feldner, 2013). For example, childhood trauma can result in emotional dysregulation which in turn creates greater susceptibility to symptoms of PTSD and psychiatric comorbidities (Crowell et al., 2015; Dvir et al., 2014). In general, PTSD symptom severity is positively associated with measures of emotion dysregulation (Powers et al., 2021; Ehring & Quack, 2010). Emotion dysregulation may be a mechanism for the development and maintenance of PTSD as impairments in emotion regulation can lead to maladaptive responses to extreme emotions that result from traumatic events including risky behavior or self harm (Weiss et al., 2012; Gratz &

Tull, 2010). Similarly, emotion dysregulation is a mediator in the relationship between PTSD symptoms and comorbidities such as dissociation (Powers et al., 2015). A review of neuroimaging studies has also supported the link between PTSD and emotion dysregulation by recognizing complications in a large neurocircuitry involving the amygdala, insula, hippocampus, anterior cingulate cortex, and prefrontal cortex (Fitzgerald et al., 2014).

B. Psychophysiological Implications of Emotion Dysregulation

a. Physiological Correlates of Emotion Dysregulation

Emotion dysregulation has also been associated with disruptions in autonomic nervous system function, specifically with cardiovascular dysregulation. Cardiovascular changes are associated with emotional response; for example, increased heart rate and blood pressure are frequently observed experiences of fear and anger (Sinha et al., 1992). These emotional responses are specifically linked to functions of neuroendocrine pathways involved in the stress response mediated by emotional arousal. The hypothalamic-pituitary-adrenocortical (HPA) pathway and the sympathetic-adrenomedullary (SAM) system are central to the stress response and associated emotion regulation. Both sympathetic and parasympathetic branches of the autonomic nervous system (ANS) are activated during emotion reactivity and regulation (Fox et al., 2012), as regulation can be conscious or unconscious (Gross, 2008; Mauss et al., 2006). Because emotions play a mediating role in the physiological responses elicited by stress (Shallcross et al., 2015; Feldman et al., 1999), physiological disruptions can be indicators of difficulty in emotion regulation (Myroniv et al., 2017).

b. Heart Rate Variability and Autonomic Functioning

One physiological assay often linked to emotion regulation is Heart Rate Variability (HRV). HRV is a physiological measure of Autonomic Nervous System (ANS) functioning that reflects the variability of time between R-R intervals in the QRS complexes of a heartbeat wave function, also referred to as an ECG waveform.

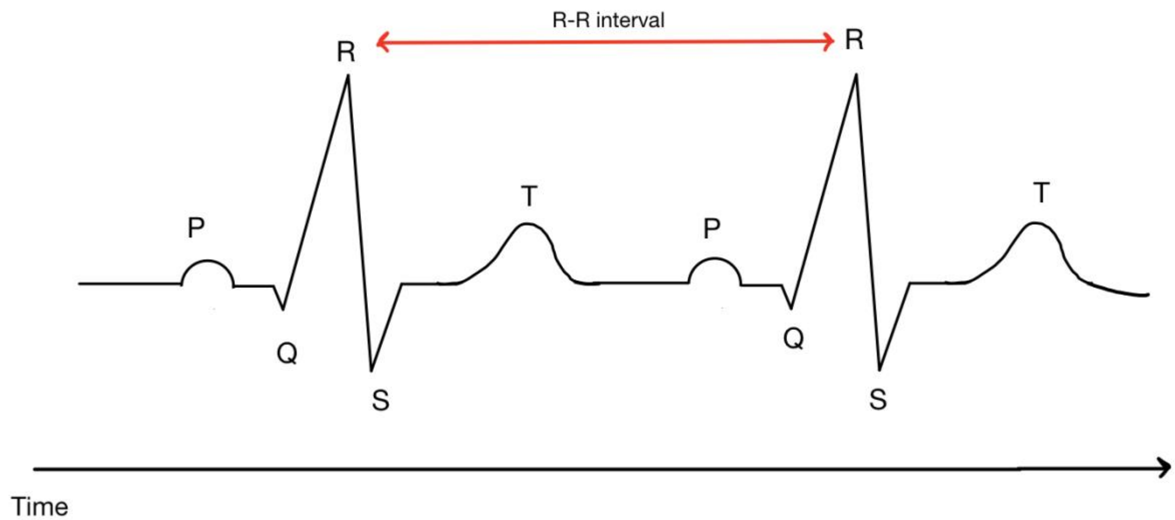


Figure 1. Visual diagram of the R-R intervals and QRS complexes of a normal ECG waveform. The P, Q, R, S, and T complexes denote stages of the heartbeat. The R peak represents heart ventricular contraction.

The ANS's two branches, the parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS), alter and regulate heart rate and rhythm in response to stimuli. In general, the parasympathetic nervous system (PNS) controls the rest and digest functions of the body by releasing the neurotransmitter acetylcholine– heart rate is slowed, and R-R intervals are lengthened. More specifically, the PNS innervates the sinoatrial (SA) and atrioventricular (AV) nodes of the heart by way of the vagus nerve. Both the SA and AV nodes are crucial in the stimulation and production of the heartbeat. The SNS, on the other hand, directs the fight-or-flight stress response and causes release of catecholamine hormones such as epinephrine and norepinephrine which in turn increase heart rate (Johnston et al., 2020). interpretations of high vs low HRV are usually relative within study samples. Commonly, a well-functioning ANS is characterized by the ability to appropriately alter activity between the PNS and SNS branches which is usually associated with comparatively high HRV. Conversely, relatively low HRV is characterized by less flexibility between branches, which manifests as autonomic imbalance in which one branch is dominant (Thayer et al., 2010; Electrophysiology, 1996). Prolonged sympathetic dominance can add to risk of developing physical and psychological health risks.

c. Reduced HRV as a Reflection of Psychopathology

Autonomic dysfunction is a systemic common denominator of poor physical and mental health, and associated cardiac dysregulation can cause the manifestation and perpetuation of broad spectrum symptoms of poor health (Shaffer & Ginsberg, 2017). HRV, as a reflection of autonomic regulation, is a medical index of morbidity and wellness. Lower HRV is linked to a range of psychiatric disorders and mental illnesses including anxiety, depression, susceptibility to substance abuse, schizophrenia, bipolar disorder, and PTSD (Benjamin et al., 2021; Moss & Shaffer, 2017; Beauchaine & Thayer, 2015; Shaffer et al., 2014; Evans et al., 2013; Beauchaine, 2001). The degree of HRV attenuation is also linked to higher severity of illness symptoms in depression, schizophrenia, and PTSD (Benjamin et al., 2021; Jung et al., 2019).

Among trauma-exposed populations, reduced HRV is commonly associated with increased PTSD-symptom severity and related psychopathologies (Dennis et al., 2014; Shah et al., 2013; Cohen et al., 2000; Cohen et al., 1997). Lower HRV was measured in response to an emotion regulation task in participants with borderline personality disorder and comorbid PTSD in relation to those without PTSD (Krause-Utz et al., 2019). In addition, increased HRV has predicted greater decrease in PTSD Symptoms in a therapy intervention group involving cognitive emotional processing of trauma (Soder et al., 2019). HRV and emotion regulation are linked in trauma-exposed populations.

d. Associations of Autonomic Regulation with Resilience to Psychopathology

Chronic stressors can lead to morbidities in forms of mental and psychological impairment which in turn prolongs the stress response and sympathetic output, contributing to a cycle of autonomic imbalance and health deficiencies (Shaffer & Ginsberg, 2017). Elevated HRV is believed to be a protective factor against psychopathologies as it has been associated with higher levels of resilience, self regulatory capacity, attentional control, and adaptability (Ramírez et al., 2015; Segerstrom & Nes, 2007; McCraty & Shaffer, 2015). Treatment methods targeting HRV augmentation through biofeedback have led to improvements in perceived stress, anxiety, and vagal modulation (Prinsloo et al., 2013; Reiner, 2008; Nolan et al., 2005). Autonomic flexibility is important in the ability to effectively respond to environments in times of strain or stress as well as maintain self-regulation (Shaffer et al., 2014; Kemp & Quintana, 2013; Servant et al., 2009).

e. HRV Measurement Methods

Several methods of measurement, including time domain analysis, frequency domain analysis, and wavelet analysis, have been used to measure HRV. Analysis periods for both can range from short-term (several minutes or less) to long-term (1-24 hours). The time domain method measures instantaneous heart rate, or the intervals between adjacent QRS complexes.

The mean and standard deviation may be taken of the intervals over a select period of time (Electrophysiology, 1996). The frequency domain method uses power spectral analysis to separate HRV into component rhythms that operate within different frequency ranges. This method considers both frequency and amplitude information about specific rhythms that exist in the HRV wave function and allows for the quantification of heart rate oscillations. The high frequency (HF) and low frequency (LF) bands are generally used to measure HRV. However, frequency domain analysis can be limited to stationary signals as they exist at one exact frequency and have no time localization (German-Sallo, 2014). The wavelet analytic technique also uses frequency domain analysis to separate HRV signals by frequency, but it allows for continuous assessment of HRV and modulation over time.

The HF band is posited to reflect parasympathetic or vagal activity (Shaffer et al., 2014). It has been suggested that the LF band could indicate sympathetic activity and that the LF/HF ratio can assess parasympathetic and sympathetic balance and interactions. However, the latter two measurements are controversial and have been persuasively refuted in the literature (Billman, 2013; Rahman et al., 2011; Heathers, 2011). HF-HRV is believed to be a reliable measurement of parasympathetic modulation as vagal activity is a major contributor to the HF component (Yilmaz et al., 2018; Electrophysiology, 1996). Therefore, HF-HRV may be used to examine autonomic activity and dysfunction.

f. Relationship between Emotion Regulation and HRV

HRV is a broad indicator of behavior and emotion dysregulation (Beauchaine, 2015; Thayer et al., 2012) and may be considered a physiological marker that contributes to emotional experience (Kemp & Quintana, 2013). The Neurovisceral Integration Model posited by Thayer and colleagues contends that HRV has a neuroanatomical basis for reflecting emotional and adaptive regulation (Thayer et al., 2012). The amygdala and medial prefrontal cortex are associated with perceptions of threat and safety and are structurally linked to HRV regulation through neural circuits (Thayer et al., 2012; Thayer & Lane, 2000). Flexible and effective emotional and behavioral responses to threat and safety can be reflected by higher HRV. In terms of psychological and behavioral association, augmented HRV signals the ability of context-based and goal-directed control of emotions. Both trait and task response studies showed that individuals with higher HRV had better emotion regulation and ability to use emotion regulation strategies (Thayer et al., 2012; Geisler et al., 2010; Fabes & Eisenberg, 1997). Relatively low resting-HRV is linked to greater difficulties in emotion regulation (Visted et al., 2017; Gerardo et al., 2016; Williams et al., 2015). Lower HRV was associated with prolonged fear and anxiety responses to startle procedures as well as higher self-reported emotion dysregulation (Bradley et al., 2011; Melzig et al., 2009; Ruiz-Padial et al., 2003). Individuals with low HRV also showed blunted post stress recovery of cardiovascular, endocrine, and immune responses (Weber et al., 2010). Emotion regulation depends on an individual's ability to rapidly adjust physiological arousal, and a flexible ANS, indexed by high HRV, allows for easier generation or modulation of physiological and emotion states (Appelhans & Luecken, 2006; Gross 1998). In this way, HRV can be used as an indicator of disrupted emotion regulation and associated comorbidities.

C. HRV Differences Between Racial Populations

a. Mental Health Disparities in Black Populations

Differences in HRV have been observed across different clinical populations and between different demographic groups. People from marginalized racial and ethnic groups, including Black individuals are thought to experience higher allostatic load due to chronic stressors resulting from perceived and structural discrimination (Duru et al., 2012; Sternthal et al., 2017). As compared to white populations, there is evidence for higher prevalence of cardiovascular disease, hypertension, obesity, and type II diabetes in Black populations (Levine et al. 2021; Muntner et al., 2018; Carnethon et al., 2017; Menke et al., 2015; Loehr et al., 2008). Prevalence of psychiatric disorders in Black populations however are seen to be similar to or lower than White populations. A review conducted by Youman and colleagues shows that Black American males compared to White American males had slightly but significantly lower prevalence of antisocial personality disorder, drug abuse/dependence, current major depression, and similar prevalence of bipolar I and II disorders (Youman et al., 2010; Harris et al., 2005). Nevertheless, it is important to note that Black populations face greater stressors including the highest poverty rates among races considered by the US Census Bureau, higher proportions and risks of incarceration, and greater exposure to discrimination (US Census Bureau, 2020; Williams, 2018; Youman et al., 2010). Black populations also have more *persistent* depression and are more likely to be exposed to traumatic events while also having less health insurance coverage and inadequate access to mental health care (US Census Bureau 2020; Budhwani et al., 2015; Roberts et al., 2011; Youman et al., 2010; Gillespie et al., 2009). Black populations are also subject to mistreatment and misdiagnosis due to lack of culturally competent care which has deleterious effects considering psychopathologies and related symptoms manifest differently across race and culture (Bell et al., 2015; Fabrega Jr. et al., 1988). Additionally, Black populations are also underrepresented in psychological research perpetuating a lack of understanding and superficial treatment approaches (Neighbors, 1990).

b. Emotion Regulation and HRV in Black Populations

Although clinical studies demonstrate relationships between emotion dysregulation and HRV, findings have been less consistent across racial groups (Farrell et al., 2020; Hill et al., 2015; Kemp et al., 2016). Because Black populations have greater prevalence of cardiovascular disease, hypertension, type II diabetes, burden of allostatic load and face higher rates of socioeconomic disadvantage and racial discrimination, it would be expected that Black populations would exhibit lower HRV than their White counterparts as lower HRV is associated with increased risk (Muntner et al., 2018; Menke et al., 2015; Carnethon et al., 2017, Thayer et al., 2010; Loehr et al., 2008; Thayer & Lane, 2007). However, Hill and authors conducted a systematic review and meta-analysis examining 17 published studies with more than 11,000 participants, observing robust racial differences in HRV, such that Black Americans showed higher HRV compared to White Americans. They termed this phenomenon as "The Cardiovascular Conundrum." Only reports of resting HRV reflecting short-term, predominantly parasympathetic activity were included in the review and the majority of effect sizes were computed from HF power. Studies also included both healthy and unhealthy populations, and Hill and authors found that the racial difference in HRV remained robust regardless of health status or medication (Hill et al., 2015). Although, they do address that some studies did show that Black Americans exhibited lower HRV than White Americans, the majority of the studies found the opposite pattern.

Another robust finding showing that Black participants displayed higher HRV than White participants was cohort study conducted by Kemp and colleagues. More than 11,000 healthy participants were recruited and resting HRV was extracted from a 10-minute resting-state cardiogram. Notably, Kemp and colleagues also presented some of the first evidence that racial differences in HRV may be partially underpinned by experience of racial discrimination as they conducted a mediation analysis from a self-report discrimination questionnaire (Kemp et al., 2016). Both authors posited that increased emotion regulation due to greater experience of racial stressors and discrimination could be the reason for higher HRV in Black populations, however their explanations were mainly speculative.

Emotion regulation, and the effort/resources that are allocated to this process, are influenced by social and cultural context, including social relationships and learning, and culturally specific emotional expression and behavior (Boiger & Mesquita, 2012; Leersnyder et al., 2013). Culture, including racial experiences and backgrounds, can influence the extent to which people are motivated to regulate their emotions and it can change the way people emotionally respond (Ford & Mauss, 2015; Leersnyder et al., 2011) This is important in the relationship between emotion regulation and psychological health as many psychological disorders are characterized by low HRV and rigid responses to the environment, not excluding their cultural surroundings (Aldao, 2013). As a result, emotion regulation may be employed differently among Black populations due to culturally distinctive values and experiences.

D. The Role of Mindfulness in Emotion Regulation and HRV

a. Mindfulness and Emotion Regulation

Interpretations of emotion regulation and HRV are highly contextual and their effects can be seen especially during emotion regulatory practices such as mindfulness. Mindfulness meditation practices have recently emerged as a method of treating PTSD, psychiatric disorders, additional comorbidities such as dissociative symptoms, and overall as a means to improve well-being. It can be defined as intentional attention to present moment experiences while calmly acknowledging physical sensations, affective states, thoughts, and imagery in a non-judgemental way (Bremner et al., 2017; Grossman et al. 2004; Miller et al., 1995). Mindfulness and emotion regulation share similar features in emotional awareness and emotional acceptance (Iani et al., 2019; Guendelman et al., 2017; Roemer et al., 2015; Hill & Updegraff, 2012). Mindfulness and emotion regulation abilities are often positively correlated and draw upon one another. Several self-report studies showed that increased emotion regulation correlated with increased mindfulness among healthy adults and college students (Roemer et al., 2015; Hill & Updegraff, 2010; Coffey & Hartman, 2008). It has also been suggested that mechanisms of emotion regulation are needed to employ and maintain mindfulness and vice versa (Vago and Silbersweig, 2012; Hölzel et al., 2011). Therefore, increased emotion dysregulation can make it difficult to engage in mindfulness, which is why improving emotion regulation may be a treatment mechanism to help engage in mindfulness thereby increasing well-being. Emotion dysregulation has been negatively associated with mindfulness in varying populations and has shown to mediate relationships between mindfulness and psychophysiological disorders. In a sample of treatment-seeking adults, emotion regulation difficulties mediated the relationship between mindfulness and both anxiety and depression (Desrosiers, et al. 2013).

b. Mindfulness and HRV

Mindfulness has also been positively correlated with HRV in that engaging in mindfulness practices can increase HRV (Krygier et al., 2013). A review of HRV and mindfulness research found multiple randomized control trials that showed a pattern of higher HRV in mindfulness practicing groups than control groups during stress tasks (Christodoulu et al., 2020; Kirk et al., 2020; Shearer et al., 2015; Garland et al., 2012; Wolever et al., 2012).

Similarly, researchers found that participants that were better able to self-regulate their attention to their breathing during a mindfulness exercise displayed significantly greater HRV (Burg et al. 2012). In congruence, HRV is a reliable index of self-regulatory effort and strength which is employed during mindfulness practice (Watford & Stafford, 2015; Segerstrom & Ness, 2007; Thompson, 1991).

E. The Present Study

This study attempts to assess the relationship between difficulties in emotion regulation and heart rate variability in a sample of trauma exposed Black Women at rest and during an emotion regulatory mindfulness task. This is done through quantitative statistical analyses and qualitative interview discussions with the participants. This study is designed to explore differences in HRV patterns in a population that has experienced multiple types of adversity and has largely been ignored in clinical neuroscience research. Therefore, understanding these relationships may shed light on factors that may increase vulnerability for mental health disparities in Black Americans.

II. Methods

A. Participants: Recruitment and Demographics

Forty-five Black women (age 18-65, Mean = 43.96, SD = 12.15) were recruited for a breath focused mindfulness meditation (BFMM) study conducted by the Fani Lab. Participants were selected through community and university flyering in the metropolitan Atlanta area where advertisements showed that participants would be involved in a clinical trial designed to treat problems related to psychological trauma and would have six sessions of breath-focused mindfulness practice (SI Fig1). Participants were also recruited from a larger parent study based in Grady Memorial Hospital known as the Grady Trauma Project. Prior to the COVID-19 pandemic, trained research staff approached potential participants at random in waiting rooms of general medical clinics. If the patient expressed interest, they were given an informed consent procedure, then administered a series of measures assessing trauma exposure, PTSD symptoms, and possible psychiatric or behavioral comorbidities. After a brief hiatus due to the COVID-19 pandemic, precautions were put in place to begin study investigations. Patients were called via telephone and invited to participate. The battery was administered through online interviews and COVID-19 symptom reports, masks, and temperature checks were required for any in-person contact.

Participants that showed interest through flyers were screened over phone for eligibility or they were referred by the Grady Trauma Project at which point eligibility was already confirmed. Inclusion criteria consisted of: 1) women between the ages of 18-65, 2) experiencing at least one DSM-5 Criterion A traumatic event, and 3) clinically significant symptoms of PTSD (score of >16 on PTSD Symptom Scale). Exclusion criteria were: 1) significant cognitive impairments as a result of neurological conditions or injuries, 2) diagnosis of diseases that affect the central nervous system and/or autoimmune system (epilepsy, multiple sclerosis, HIV/AIDS, etc.), 3) meeting criteria for primary psychotic disorder, bipolar disorder, or schizophrenia, and 4) acute suicidal ideation.

The original BFMM study recruited a larger sample, however for the purposes of the current study, analyses were restricted to Black women who completed both the clinical and physiological measures being investigated. Notable characteristics of the participant group: 60% of participants were unemployed, 62.3% completed high school, GED, or some college/technical school, and 68.9% earned a monthly income of less than $2000.

Table 1. Demographic Characteristics of Participant Group

Participant Characteristics (N=45)	Mean (SD) or %
Age	43.96(12.15)
Level of Education (%)	
Less than 12th Grade	15.6
12th Grade/High School Graduate	15.6
GED	8.9
Some College/Technical School	22.2
Technical School Graduate	11.1
College Graduate	15.6
Graduate School	11.1
Employment (%)	
Yes	40.0
No	60.0
Monthly Household Income (%)*	
$0-249	15.6
$250-499	6.7
$500-999	20.0
$1000-1999	26.7

$2000-more	31.1

*Value not collected from one participant

B. Clinical Measures

The primary clinical measure used in data analysis and for measuring capacity of emotion regulation was the Difficulties in Emotion Regulation Scale (DERS). The Traumatic Events Inventory (TEI) and Modified PTSD Symptom Scale (MPSS) were administered to measure trauma load and PTSD symptom severity of the sample. All clinical measures were taken prior to any mindfulness intervention in the BFMM study.

Difficulties in Emotion Regulation Scale (DERS): The Difficulties in Emotion Regulation Scale is a 36-item self report measure that assesses impairment, or dysregulation, in ability to regulate one's emotions. Higher numbers on the scale indicate greater difficulties in emotion regulation. The DERS measure has shown to have clinical and predictive utility in treatment seeking adults (Gratz & Roemer, 2004; Hallion et al., 2018), specifically in Black trauma-exposed women (Mekawi et al., 2020). Subscales of DERS include: Non-Acceptance of Emotional Responses, Difficulty Engaging in Goal-Directed Behavior, Impulse Control Difficulties, Lack of Emotional Awareness, Limited Access to Emotion Regulation Strategies, and Lack of Emotional Clarity.

Traumatic Events Inventory (TEI): The Traumatic Events Inventory is a 14-item screen that measures exposure to traumatic events throughout life (Gillespie et al., 2009). It assesses experiencing, witnessing, and being confronted with specific types of trauma. Trauma events endorsed on the TEI represent Diagnostic and Statistical Manual, version 5 (DSM-5) criterion A events for PTSD.

<u>Modified PTSD Symptom Scale (MPSS)</u>: The Modified PTSD Symptom Scale is a 17-item self report inventory that measures frequency and intensity of PTSD symptoms (Ruglass et al., 2014). MPSS demonstrated internal consistency and was found to be a reliable and valid tool to assess and monitor changes in PTSD symptoms (Falsetti et al., 1993; Ruglass et al., 2014). MPSS has been used among multiple community samples who report a wide range of traumatic events (Falsetti et al., 1992; Powers et al, 2020). Dimensions of MPSS are Re-Experiencing, Avoidance and Numbing, Hyperarousal, and Anhedonia.

C. Descriptive Statistics of Clinical Measures in Sample

Table 2. Summary of Difficulties in Emotion Regulation (N=45)

DERS	Mean Score (SD)
Total Score	91.44(27.66)
Non-Acceptance	15.71(7.36)
Goals	15.36(5.59)
Impulse	13.80(6.32)
Strategies	21.04(8.08)
Clarity	11.20(4.51)

*Non-acceptance, Goals, Impulse, Strategies, and Clarity refer to subscales of DERS

Table 3. Summary of Traumatic Events Inventory (TEI)

<u>Trauma Exposure:</u> Participants on average experienced **5.28(SD= 2.56; N=43)** traumatic events. Further breakdown of trauma types and number of participants exposed to each trauma type are given in the table below.*

Trauma Type Experienced	(# of Participants), Percentage(%)
Any Significant Trauma (N=43)	(43), 100%

Natural Disaster	(19), 42.2%
Serious Accident or Injury	(30), 66.7%
Sudden Life Threatening Illness	(19), 42.2%
Military Combat	(1), 2.2%
Attacked with knife, gun or other weapon by someone other than intimate partner (N=43)	(11), 24.4%
Attacked with knife, gun or other weapon by intimate partner (N=44)	(15), 33.3%
Attacked without a weapon by someone other than intimate partner (N=44)	(17), 37.8%
Attacked without a weapon by intimate partner (N=44)	(24), 53.3%
Witness/Confronted with Murder of Friend or Family Member	(28), 62.2%
Sexual Contact 17 years and older with physical force (N=43)	(15), 33.3%
Sexual Contact aged 14-17 years with physical force (N=44)	(16), 35.6%
Sexual Contact aged 13 years and younger (N=44)	(23), 51.1%
Beaten as a Child (N=44)	(20), 44.4%

*Note. N=45 unless otherwise specified; Some values missing because participants declined to answer, therefore N may vary in each trauma-type category

Table 4. Summary of PTSD Symptom Severity (N=45)

MPSS	Score
Total Score	28.82(9.42)
Re-Experiencing	7.69(3.75)
Avoidance and Numbing	11.60(4.67)
Hyperarousal	9.53(3.12)
Anhedonia	5.09(2.52)

*Re-experiencing, Avoidance and Numbing, Hyperarousal, and Anhedonia refer to subscales of MPSS

D. Breath Focused Mindfulness Meditation (BFMM) Study and Intervention

The Breath Focused Mindfulness Meditation (BFMM) Study was conducted to investigate potential alleviation of dissociation, PTSD symptoms, and comorbidities among a sample population of treatment seeking, trauma-exposed women through a physiologically augmented breath focused mindfulness practice. Participants were randomly assigned to a BFMM as normal control group or a vibroacoustically-augmented BFMM experimental group where participants received vibroacoustic feedback from a device placed at their sternum; participants would breathe into a microphone which proportionally translated auditory signals from their breathing into the vibrations from the device. Breathing into the microphone resulted in vibrations for the BFMM experimental group; those in the control group also wore the device but received no vibration feedback.

After initial screening and administration of consent procedures, participants completed a psychodiagnostic interview confirming PTSD diagnosis and ruled out any exclusionary study diagnoses. At each of the six intervention sessions, participants were seated in a soundproof booth in front of a computer screen while being closely video monitored by a research assistant. Participants were read the overall instructions prior to the intervention and also informed of any safety precautions.* Condition tasks appeared on the computer screen during the intervention where participants were instructed to either engage in BFMM (breathe into the microphone, focus on breath away from the microphone) or to rest and relax, for 1 minute in each condition. The conditions were randomized, and the total session time was 15 minutes.

*Instructions displayed on a monitor and read to the participant by the research assistant verbatim:

"You will be asked to either rest or pay attention to your breathing. When paying attention to your breathing, bring the microphone to your nose and breathe into it. Paying attention to your breathing means: pay attention to what you feel in your body as you breathe. Focus your awareness on any physical feeling you may experience (like your belly rising). Pay attention to your body as you breathe in, all the way through until your breath leaves your body. There is no need to control your breathing in any way. Just let yourself breathe normally. Sometimes you will be asked to rest. During those times, push the microphone away from you. Keep your eyes open when you rest."

E. Physiological Measures

Electrocardiographic recordings took place during BFMM intervention sessions, which involved one minute alternating breath focus and rest conditions. The original study administered six intervention sessions over three weeks, however Heart Rate Variability (HRV) was considered from only the first session to assess baseline HRV.

Electrocardiogram (ECG): Electrocardiogram data was taken at rest and during the mindfulness breath focus condition. Electrode leads were placed at the radial artery (left wrist) and carotid artery (neck under the right ear). Data was collected over the 15-minute intervention session throughout the different conditions. The order of conditions were randomized in the first three minutes and that order was then repeated for the remaining time. ECG data was collected using AcqKnowledge software (BIOPAC System, Inc.).

Heart Rate Variability (HRV): Heart Rate Variability (HRV) data was preprocessed using a custom MATLAB toolkit created by Dr. Greg Siegle, a FANI Lab partner investigator at the University of Pittsburgh (https://www.pitt.edu/~gsiegle/). Data was reviewed and checked for quality assurance (QA) with QA metrics set as: heart rate between 40-120 beats per minute; no significant spikes or ectopic beats; and electrocardiograms that appear normative with distinct R peaks in QRS complexes. The QRS complex represents depolarization of the ventricles and the R peak heart ventricular contraction. In addition, study staff manually reviewed participant sessions that fell outside expected values (i.e. fail QA) and corrected them if possible or were removed from analyses. All HRV data were then manually rechecked to correct any minor errors and to confirm inclusion/exclusion of the data file. Wavelet analytic technique analysis was used to determine High-Frequency Heart Rate Variability (HF-HRV; 0.15Hz - 0.40Hz). HF-HRV data were analyzed using SPSS software version 28. Average HF-HRV was examined across a 1-minute timespan as well as 15 second subintervals for both the rest and breath focus conditions to examine potential associations of DERS and HRV at different time points throughout the rest and breath focus conditions.

Table 5. Mean HRV-Averages in Rest vs Breath Focus Condition in Each Time Interval.

	Condition	
HF-HRV Time Interval	Rest	Breath-Focus
1 minute	-.11	.09
0 to 15 seconds	.04	.22
15 to 30 seconds	-.13	.11
30 to 45 seconds	-.22	-.11
45 to 60 seconds	-.18	-.12

F. Statistical Analysis

All statistical analyses were conducted with SPSS software version 28. A repeated measures analysis was conducted to see effects of DERS, time, and condition on HRV. Pearson correlations were used to assess the relationship between DERS and HF-HRV. Average HF-HRV over various time intervals (1 minute, 0-15 seconds, 15-30 seconds, 30-45 seconds, 45-60 seconds) were used in separate correlations with DERS to investigate specificity of timepoints and effects from rest vs breath focus conditions. Possible moderations of physiological augmentation in the breath focus condition and possible moderations of trauma load were assessed by using the Hayes Process MACRO v4.

G. Participant Narratives

Post-intervention participant interviews were conducted by research assistants to receive feedback and narratives of participants' experiences of mindfulness meditation and the BFMM Study. They were short, semi-structured interviews that allowed participants to reflect on their experience in the study and gave researchers ideas for improvements and direction in future studies.

III. Results

A. Condition, Time, and DERS Effects on HRV

A repeated measures analysis was used to determine condition, time, and DERS effects on HF-HRV.

Table 6. Effects of Condition, Time, and DERS on HF-HRV (N=45)

	F	p-value
Condition	9.66*	.003
Condition x DERS	13.98*	<.001
Time	.33	.80
Time x DERS	.70	.56
Condition x Time	3.15*	.03
Condition x Time x DERS	2.67	.05

HF-HRV significantly differs across rest and breath focus conditions, as well as across conditions at varying levels of DERS. HF-HRV does not differ across time segments alone, however HF-HRV significantly differs in different time segments across conditions. Additionally, the condition x time x DERS effects on HF-HRV are approaching significance in that HF-HRV differs across conditions, in different time segments, at varying levels of DERS.

B. DERS and HF-HRV Correlations During Rest and Breath Focus Condition

Pearson correlations were conducted between baseline DERS and HF-HRV at both the rest and breath focus conditions. Correlation analyses included DERS total scale and subscales as well as HF-HRV averages over a 1-minute time interval and 15-second subintervals. Average HF-HRV over the full 1-minute time interval had no significant correlations with DERS total scale or subscales; however, when assessing specific 15-second time intervals, opposite patterns emerged among the two conditions. All significant correlations between baseline DERS and HF-

HRV in the rest condition presented a negative relationship, conversely all significant correlations between baseline DERS and HF-HRV in the breath focus condition presented a positive relationship. All correlations are shown in Table 7.

Table 7. Correlations Between DERS and HF-HRV at various time intervals

	HF-HRV	
DERS	Rest	Breath Focus
	1-minute Time Interval	
Total Score	-.18	-.01
Non-Acceptance	-.00	-.03
Goals	-.08	-.15
Impulse	-.27	-.02
Strategies	-.21	.08
Clarity	-.05	-.03
	0 to 15 seconds Time Interval	
Total Score	-.06	.35**
Non-Acceptance	-.01	.39***
Goals	-.22	.15
Impulse	.01	.11
Strategies	-.13	.17
Clarity	-.10	.41***
	15 to 30 seconds Time Interval	
Total Score	-.30*	.22
Non-Acceptance	-.22	.26
Goals	-.26	.13
Impulse	-.32*	-.03
Strategies	-.25	.15
Clarity	-.30*	.20
	30 to 45 seconds Time Interval	
Total Score	-.34*	.31*

Non-Acceptance	-.37*	.31*
Goals	-.28	.31*
Impulse	-.27	.07
Strategies	-.24	.28
Clarity	-.33*	.19
45 to 60 seconds Time Interval		
Total Score	-.41***	.32*
Non-Acceptance	-.46***	.30*
Goals	-.35*	.34*
Impulse	-.23	.15
Strategies	-.32*	.31
Clarity	-.35**	.18

Note. N=45 for all correlations. Non-Acceptance, Goals, Impulse, Strategies, and Clarity represent the DERS subscales. Significance values represented as *p<0.05, **p<0.02, ***p<0.01

HRV during Rest

HF-HRV was negatively associated with: DERS total score (r= -.30, p<0.05) and DERS impulse (r= -.32, p<0.05) and clarity (r= -.30, p<0.05) subscales in the 15-30 second interval, DERS total score (r= -.34, p<0.05) and DERS non-acceptance (r= -.37, p<0.05) and clarity (r= -.33, p<0.05) subscales in the 30-45 second interval, and DERS total score (r= -.41, p<0.01) and DERS non-acceptance (r= -.46, p<0.01), goals (r= -.35, p<0.05), strategies (r= -.32, p<0.05) , and clarity (r= -.35, p< 0.05) subscales in the 45-60 second interval.

Correlations were particularly strong for the 45-60 seconds time interval relative to other intervals. Additionally, the DERS non-acceptance subscale had the strongest negative association with HF-HRV among specific time intervals (30-45s: r=-.37, p<0.05; 45-60s: r= -.46, p<0.01), and the DERS clarity subscale, other than the DERS total score, showed the most consistent negative association with HF-HRV across three separate time intervals (p<0.05 at 15-30s, 30-45s, and 45-60s).

<u>HRV during Breath Focus</u>

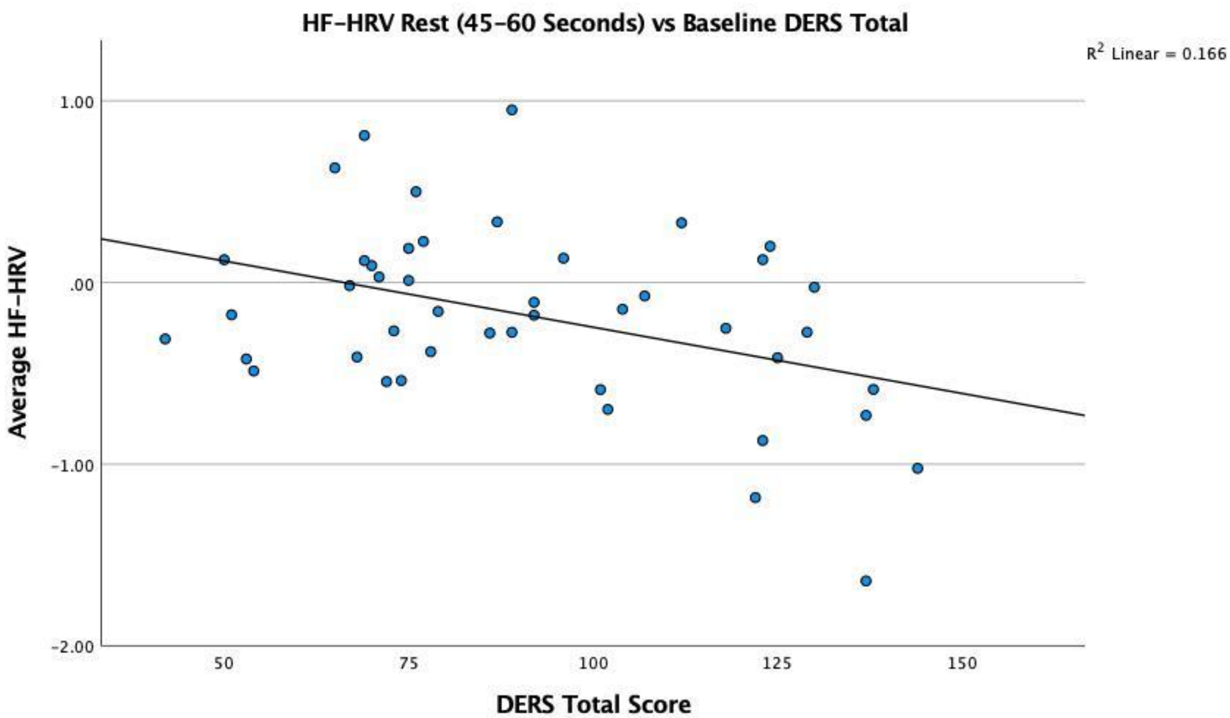
HF-HRV was positively associated with: DERS total score ($r = .35, p < 0.02$) and DERS non-acceptance ($r = .39, p < 0.01$) and clarity ($r = .41, p < 0.01$) subscales in the 0-15 second time interval, DERS total score ($r = .31, p < 0.05$) and DERS non-acceptance ($r = .31, p < 0.05$) and goals ($r = .31, p < 0.05$) subscales in the 30-45 second time interval, and DERS total score ($r = .32, p < 0.05$) and DERS non-acceptance ($r = .30, p < 0.05$) and goals ($r = .34, p < 0.05$) subscales in the 45-60 second time interval. Correlations were particularly strong in the 0-15 second time interval.

C. Visual Representation of DERS and HF-HRV Relationships in Rest and Breath Focus Condition

Correlations are shown as scatterplots to better visualize the differing relationships between DERS and HF-HRV in the two conditions.

Figure 3

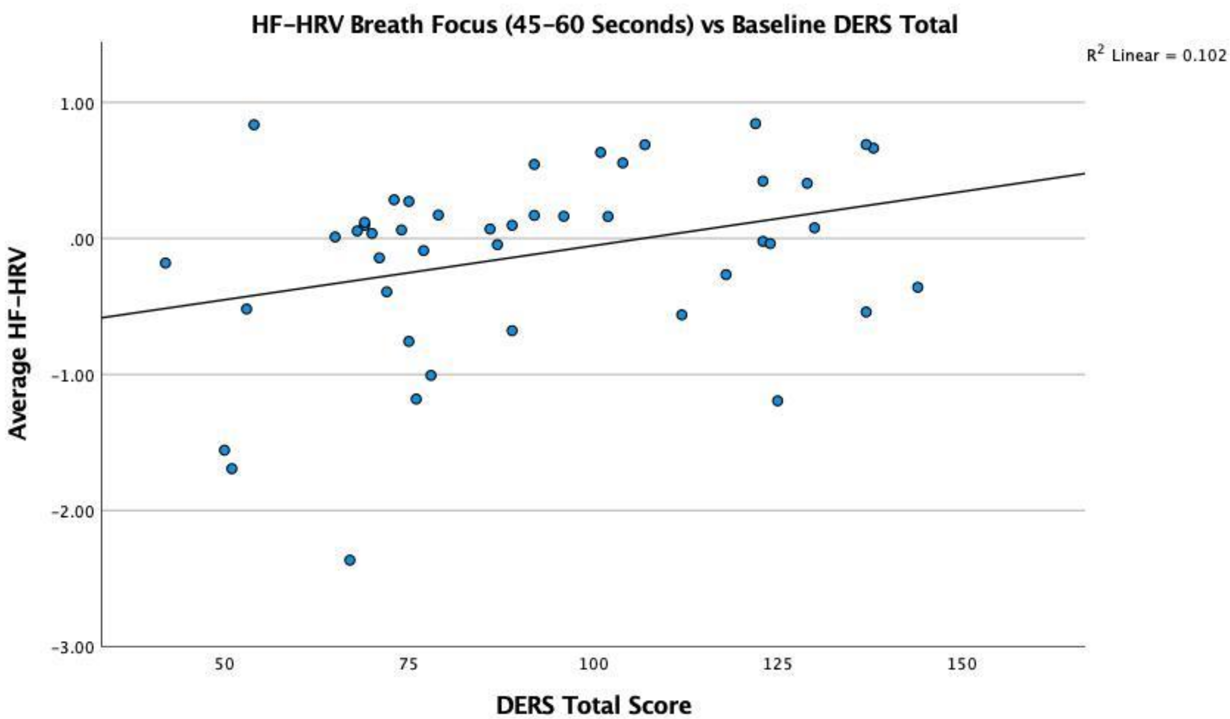
Average HF-HRV Rest 45-60 Seconds vs DERS Total



Note. Scatterplot of average HF-HRV in rest condition at the 45-60 second time interval and baseline DERS Total (r= -.41, p= .006).

Figure 4

Average HF-HRV Breath Focus 45-60 Seconds vs DERS Total



Note. Scatterplot of average HF-HRV in breath focus condition at the 45-60 second time interval and baseline DERS Total (r= .32, p= .032).

D. Possible Moderation Effects on DERS and HF-HRV Relationship

Hayes PROCESS v4 Model was used to determine moderation effects of intervention groups and trauma load, separately, on the association between DERS and HF-HRV across both conditions and in all time intervals. No significant interaction for the intervention group appeared in the relationship between DERS and HF-HRV. Some significant interactions for trauma load appeared in time intervals in both conditions.

Table 8. Intervention Group Interactions

Time Interval	Interaction Coefficient	p-value
1 minute	.001	.82

0-15 seconds	-.004	.41
15-30 seconds	-.004	.62
30-45 seconds	-.01	.20
45-30 seconds	-.005	.52

Note. Physiological augmentation interaction in the breath focus condition in different time intervals are presented.

Table 9. Trauma Load Interactions

Rest Condition		
Time Interval	Interaction Coefficient	p-value
1 minute	-.002*	.02
0-15 seconds	-.001	.26
15-30 seconds	-.001	.31
30-45 seconds	-.002*	.02
45-60 seconds	-.001	.13
Breath Focus Condition		
Time Interval	Interaction Coefficient	p-value
1 minute	.002*	.01
0-15 seconds	.000	.10
15-30 seconds	.001	.58
30-45 seconds	.001	.46
45-60 seconds	-.000	.79

Note. Trauma load interaction in both conditions across all time intervals are presented. Trauma load was assessed using the Traumatic Events Inventory (TEI).
*significant p-value

Table 10. Trauma Moderations on DERS and HF-HRV Associations in 1 minute

Rest Condition		
Trauma Load	Correlation	p-value
4.04	.006	.25
8.00	-.006	.87

13.00	-.009*	.02
Breath Focus Condition		
Trauma Load	Correlation	p-value
4.04	-.01*	.02
8.00	-.01	.11
13.00	.004	.25

Note. DERS and HF-HRV associations are shown at different levels of trauma load in the 1 minute time interval of different conditions.
*significant p-value

In the rest condition, higher levels of trauma load showed a significant negative correlation of DERS and HF-HRV (r= -.009, p=.02), but not at lower levels of trauma. In the breath focus condition, lower levels of trauma load showed a significant negative correlation between DERS and HF-HRV (r=-.01, p=.02), but not at higher levels of trauma.

E. Participant Narratives

Participants were given a post-intervention interview by a research assistant to allow participants to share any feedback or concerns. Below are some testimonials and answers to interview questions that mention any physiological or emotional experiences during the mindfulness meditation sessions.

Participant Testimonial 1:

Interviewer: Is there is anything that you particularly liked or enjoyed about the treatment?

Participant: Oh umm, just learning how to be able to meditate and how to be able to relax.

Interviewer: What did you like about learning how to meditate and relax?

Participant: Just being able to focus on what was going on

Interviewer: Do you think that the treatment was helpful?

Participant: Yes. Very helpful.

Interviewer: Could you explain how being able to meditate and relax helps you?

Participant: It's helpful period. I had to use it today. Today I woke up to my apartment flooded so I most definitely had to take some moments and breathe and calm down and focus on breathing and calm down.

Interviewer: Is there anything about the treatment that you disliked?

Participant: No. No. No. Not at all

Interviewer: Going back to how you used breathing exercises to help you calm down earlier today—can you explain more about how you used the breathing technique you learned during treatment?

Participant: I tend to get angry quickly or frustrated pretty quickly and just being able to try and make an actual effort to stay calm or focus on a particular thing—like during the breathing I can focus on something else and calm myself down

Interviewer: Explain any experience you had while you were doing the breathing exercises during your sessions.

Participant: I was able to pay attention more so to what was going on. It really seemed like I was able to focus more on how I felt. I wasn't sleepy, but I did a lot of yawning. Normally I'm not able to pay attention to how I'm feeling but as I was relaxing, I was really able to zone in on how I felt at the moment.

<u>Participant Testimonial 2:</u>

Interviewer: Is there anything that you particularly liked or enjoyed about the treatment? If so, can you explain it?

Participant: Yes. Umm, the breathing exercises and I liked being able to write out my emotions before and after the breathing exercise. I was able to see a change.

Participant Testimonial 3:

Interviewer: In what ways would you say that [this treatment] has helped?

Participant: "Um I'm able to think things a little bit easier, thoroughly, fairly. To be able to think before I react."

Participant Testimonial 4:

Interviewer: What did you enjoy about participating with us?

Participant: The meditation, the monitoring my heart while I breathe.

Interviewer: And how did that help you?

Participant: It helped me a lot because I be stressed out a lot and that really gave me some coping skills.

Overall, there was a pattern among the collected testimonials that participants felt the intervention was too short and that they found the breathing techniques to be helpful.

IV. Discussion

A. Review of Study

This study examined relationships between difficulties in emotion regulation and heart rate variability in a sample of trauma-exposed Black women. Associations were examined among two different conditions (rest vs breath focus) as part of a larger breath focused mindfulness meditation (BFMM) study. The results showed that greater baseline emotion dysregulation (DERS total) was correlated negatively with HRV during rest and positively with HRV during a breath focus condition at specific time segments. Prior research found that greater difficulties in emotion regulation are linked to low HRV in general populations, however this is the first study, to our knowledge, to investigate the relationship between emotion regulation and HRV during a mindfulness breath focus condition.

B. Finding Implications

a. HRV at Rest

The results of this investigation show that greater difficulties in emotion regulation were linked to lower HRV at rest in this sample of Black American women. These findings provide additional evidence that disrupted emotion regulation is related to autonomic inflexibility *during rest*. Both Visted and Williams found similar results in their research showing that there was a negative relationship between difficulties in emotion regulation and resting HRV in non-psychiatric samples; however, these studies did not examine differences in the context of race, stressful events, or task engagement (Visted et al., 2017; Williams et al., 2015). Environmental and cultural contexts such as stressful events, racial background, and task engagement can impact emotional responding thereby altering physiology and associations between emotion regulation and HRV (Haliczer et al., 2020; Aldao, 2013; Butler et al., 2007). Therefore, it is important to assess HRV in these contexts.

b. HRV during Breath Focus Condition

The direction of the relationship between DERS and HRV during the breath focus condition (positive correlation) contrasted with the direction of associations between DERS and HRV at rest (negative correlation). Results showed that there was an overall positive relationship between DERS and HRV where increased baseline difficulties in emotion regulation was associated with increased HRV in the breath focus mindfulness meditation condition. This could imply that greater difficulties in emotion regulation is linked to more *effortful* use of emotional regulation resources and increased engagement of autonomic systems, as reflected by higher HRV during a mindfulness meditation practice.

Trait mindfulness and mindfulness training is linked to better emotion regulation as well as increased HRV (Kirk & Axelson, 2020; Roemer et al., 2015; Hill & Updegraff, 2010; Coffey & Hartman, 2008). Additionally, HRV is an index of self-regulatory effort and strength which is employed during mindfulness practice (Watford & Stafford, 2015; Segerstrom & Ness, 2007; Thompson, 1991). Because features of emotion regulation and mindfulness are similar and draw upon one another, increased baseline difficulties in emotion regulation may require more effort for participants to engage in emotion regulation when participating in the mindfulness meditation task.

Therefore, for individuals experiencing greater difficulties in emotion regulation, particularly minority individuals who experience systemic oppression and race-related stress, it is possible that this was associated with a greater need for self-regulation capacity and emotion regulation efforts, reflected by higher HRV, to participate in the mindfulness task. This is further supported by the participant narratives given in the post-intervention interview of the BFMM study. When asked about how she used the breathing technique outside of the sessions, one participant answered, “I tend to get angry quickly or frustrated pretty quickly and [I] try and make an actual effort to stay calm or focus on a particular thing,” confirming the effortful emotion regulation needed to employ mindfulness.

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c. Associations of Emotion Dysregulation Dimensions with HRV

The subscales give insight into the disrupted dimensions of emotion regulation. In particular the non-acceptance subscale (tendency for negative secondary responses to emotions or the inability to accept emotions, ex. “When I am upset, I become angry with myself for feeling that way”), the clarity subscale (the extent to which individuals are unclear about which emotions they are experiencing, ex. “I have difficulty making sense out of my feelings”), and the goals subscale (difficulties engaging in goal-directed behavior, ex. “When I’m upset, I have difficulty concentrating”; Gratz & Roemer, 2004; Kaufman et al., 2016) had strong or consistent associations with HRV in the rest and breath focus conditions through various time intervals.

There was a negative relationship between the DERS subscales and HRV during the rest condition. This could imply a lack of effort to engage with these dimensions of emotion regulation at rest. Previous findings have shown similar difficulties in maintaining acceptance and clarity dimensions of emotion regulation. One such study showed that Black women with PTSD and substance use disorder had increased difficulty in controlling impulsive behavior and accessing emotion regulation strategies when distressed, as well as a general lack of emotional clarity (Weiss et al., 2012).

Conversely, there was a positive relationship between the same DERS subscales and HRV in the breath focus mindfulness condition implying that at higher levels of baseline difficulties in emotion regulation subscales, there was increased effort in trying to engage in that dimension of emotion regulation indicated by higher HRV. Interestingly, the acceptance, clarity, and goals subscales are aspects of emotion regulation that are also involved in mindfulness (Iani et al., 2019; Guendelman et al., 2017). This further demonstrates the efforts needed to engage in emotion regulation when participating in a mindfulness or emotion regulatory task, especially when access to such emotion regulation resources is disrupted.

d. Associations of Emotion Dysregulation and HRV in Time Intervals

The negative associations of DERS and HRV in the rest conditions were particularly strong in the last time interval, and positive associations of DERS and HRV in the breath focus condition were particularly strong in the earlier time intervals. It is possible that in the rest condition, with greater emotion dysregulation, there is increased autonomic dysregulation as time continues. In the breath focus condition, it is possible that associations become more inconsistent as time continues because with greater emotion dysregulation, autonomic engagement and effortful emotion regulation becomes more difficult to maintain through all time intervals. Notably, HRV was assessed only from the first mindfulness meditation intervention session and participants likely had little to no experience with mindfulness meditation. Mindfulness may be difficult to engage in consistently for unpracticed or inexperienced people.

e. Moderation of Trauma on Associations of DERS and HF-HRV

Emotion dysregulation has been considered a feature of PTSD and is related to trauma experience (Badour & Feldner, 2013) . The results of this study found that at higher levels of trauma types experienced in the rest condition, emotion dysregulation (DERS total score) and HRV were negatively associated. This may show that higher levels of trauma and emotion dysregulation can be associated with greater autonomic dysregulation at rest. However, in the breath focus condition, at lower levels of trauma, emotion dysregulation (DERS total score) and HRV were also negatively associated, but high levels of trauma. It could be that at lower levels of trauma and higher levels of emotion dysregulation during an emotion regulation task, there is less physiological engagement or self-regulatory efforts, reflected by lower HRV. Similar to earlier findings in this study showing increased emotion dysregulation, particularly for minority populations that face greater stressors, may employ greater effortful physiological engagement; this finding may show that participants with lower levels of trauma, or lower levels of stress, and increased emotion dysregulation are associated with decrease effortful autonomic regulation during a task reflected by lower HRV. Therefore, populations or individuals that experience lower levels of stress may employ less efforts of autonomic regulation during emotion regulation events. This may further the necessity to look at stress and other related contexts when interpreting HRV.

f. Extending “the Cardiovascular Conundrum”

Hill and colleagues termed the pattern of increased HRV in Black populations compared to White populations as “the Cardiovascular Conundrum" (Hill et al., 2015). Upon finding the same results in a cohort study of healthy adults, both Hill and authors and Kemp and authors proposed that comparatively increased HRV could be due to a heightened yet forced capacity to regulate emotions related to stressors and discrimination against Black individuals (Hill et al., 2015; Kemp et al., 2016). Racial discrimination is emotion eliciting and requires the ability to manage emotions in adaptive ways (Riley et al., 2021; Jones et al., 2014; Carter, 2007). Black populations face disproportionately high rates of racial discrimination and racial stressors thus employ emotion regulation in order to respond or cope with such stressors (Wilson & Gentzler, 2021; Jones et al., 2014). In this case, discriminatory events may also be considered emotion regulation events. The results of the current study show that greater emotion dysregulation may be associated with greater efforts of engagement with autonomic systems and emotion regulation resources, reflected by higher HRV, during an emotion regulatory task. So, higher rates of emotion dysregulation in minority populations may relate to higher HRV when experiencing stress and discrimination.

Populations that face systemic oppression and chronic stress may engage with effortful emotion regulation more often, however empirical investigations about the differences in emotion regulation and their frequency of use, particularly across race, are scarce. A systematic review conducted by Weiss and colleagues attempted to consolidate the limited research on emotion regulation across multiple racial and ethnic groups, and found that in several studies, Black Americans showed higher levels of emotion dysregulation compared to their White counterparts (Weiss et al., 2021; Schick et al., 2020; Morelen et al., 2012; Newhill et al., 2009).

The results of this study extend Hill and Kemp’s proposal that emotion regulation may be a reason for higher resting HRV in Black populations compared to White populations; rather than greater capacity for emotion regulation in Black populations, it may be that increased emotion dysregulation in Black populations is associated with more effortful autonomic regulation when experiencing discrimination and race-related stress. Once again, this calls on the consideration of stress experiences, or cultural and situational contexts when interpreting HRV especially among different racial populations.

g. Interpreting HRV in People from Minoritized Racial Groups

While relatively high HRV has been known to be a correlate of increased emotion regulation, this study provided novel evidence that increased difficulties in emotion regulation were associated with increased HRV during an emotion regulation task in a sample of a minority racial group. This could introduce the question of whether resting HRV alone is a good index of beneficial psychophysiological health correlates such as emotion regulation in minority racial groups.

When examining HRV across racial populations one should consider the cultural and situational context in which they make interpretations. One study conducted by Dorr and authors showed that even though Black participants have higher HRV at baseline than White participants, their recovery from stress tasks or laboratory-simulated threats of discrimination is delayed. Dorr and authors found that Black American men exhibited higher HRV than White American men at rest, but during a race related debate with a White confederate as compared to a neutral non-race related debate, Black American men were not able to recover to their baseline resting HRV after the debates as quickly as White American counterparts (Dorr et al., 2007). Even though resting HRV is higher in Black populations than White populations perhaps due to emotional and physiological engagement, they still show less ability to recover to their baseline HRV which can also lead to adverse health (Brook & Julius, 2000).

The present study shows that context is important in the associations between emotion regulation and HRV–that resting HRV alone does not provide a comprehensive picture of psychophysiological health correlates; and previous studies such as the one conducted by Dorr and colleagues shows that resting HRV alone does not show the effects of race-related stress. It is important to recognize that HRV may have acted as a correlate of *effortful* regulation of psychological and physiological processes as presented by this study, but resting HRV may not serve as an index of health correlates in minority populations as Black populations particularly still carry a disproportionate burden of health issues and stress due to systemic oppressions and racial discrimination.

V. Limitations

There are some limitations that exist when interpreting the results of this study. The sample size was relatively small and having more participants would increase the statistical power of the study providing better validation for the results. The Difficulties in Emotion Regulation (DERS) measure was also a self-report measure which can introduce recall biases. Additionally, the study sample only reflected primarily low-income, trauma-exposed Black women seeking treatment which may also limit the applicability of the results to larger populations. Investigating correlations between emotion regulation and HRV in Black, White, and other racial population samples would provide empirical evidence in regard to emotion regulation differences and the relationship with HRV across racial groups. In addition, while mindfulness meditation and response to discrimination events do both employ emotion regulation, they are not exactly the same– examining associations between emotion regulation and HRV during a discrimination task compared to during rest would increase validity of the presented interpretations.

VI. Further Directions

Future directions of this study would include comparing baseline emotion dysregulation as well as correlation analyses of emotion dysregulation and HRV between both Black and White populations. This would allow for better understanding of differences in emotion regulation across racial groups and give insight into their physiological engagement. In addition, it would be apt to measure associations among both racial groups and also during rest and during a discrimination task instead of a mindfulness meditation task. This would provide more direct evidence about the role of emotion regulation in discrimination, emotional responding to discrimination between racial groups, and the changes in HRV during rest and during discrimination tasks between racial groups. This would give better empirical insight into the patterns of higher HRV in Black populations compared to White populations. Additionally, investigating how specific emotion regulation strategies or coping styles that are often employed by minority populations can affect HRV and physiological processes could provide more detail about HRV trends and interpretations across racial populations.

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VIII. Appendix

A) Recruitment Flyer

The Fani Affective Neuroscience (FANs) lab is currently recruiting participants for **a clinical trial designed to treat problems related to psychological trauma.**

This involves six sessions of a breath-focused mindfulness practice, pre- and post-treatment assessments of mood and cognition. Study participants will be compensated for their time.

Who May be Eligible:

Women between the ages of 18 and 65 who have a history of trauma and symptoms of posttraumatic stress disorder (PTSD)

No history of bipolar disorder or neurological disorders (for example epilepsy)

All procedures take place at the Glenn Memorial Building located at 69 Jesse Hill Jr Drive SE, Atlanta, GA 30303

MRI eligible participants will complete MRI testing at the Center for Advanced Brain Imaging located at 831 Marietta St NW, Atlanta, GA 30318

For more information:

Contact: The FANs lab at **404-778-5767**

Email: gtpaffectneurolab@emory.edu

Website: http://www.psychiatry.emory.edu/research/laboratories/fani/index.html

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B) Semi-Structured Interview Questions:

1. Is there anything that you particularly liked or enjoyed about the treatment? If so, can you explain it?
2. Is there anything about the treatment that you disliked?
3. Was there anything you wanted to change?

Follow-up questions were asked based on answers regarding specific feelings, thoughts, behaviors during interventions and use of intervention techniques outside of the study.