Posttraumatic Stress Disorder Vulnerability in Women:
The Neuropsychological Impact of Emotional Trauma from Rape

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Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Psychology

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May 14th, 2019
Blacksburg, VA

Keywords: Sexual Trauma, PTSD, Rape, Capacity Theory, Neuropsychology, Restraint, Psychophysiology, Functional Neural Systems

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Academic Abstract

The current experiment aims to integrate the neuropsychological and physiological consequences of rape trauma and physical restraint. Given the preponderance of rape on college campuses, it is important for continued research efforts to provide insight into the impact that this traumatic experience may have on the victim. Moreover, it is expected that an improved understanding of these consequences and mechanisms will provide a foundation for prevention and treatment efforts. Within this context, capacity theory provides a basis for appreciating that extreme stress may alter and/or damage neural systems principally associated with the regulatory control or inhibition over brain regions directly involved in the experiential processing and/or comprehension of the traumatic event. The aim of the present experiment was to explore how the experience of rape trauma may alter or diminish this capacity, resulting in deregulation, heightened reactivity, and sensitivity to decomposition from subsequent exposure to these events. It was hypothesized that individuals with resultant capacity limitations would differ in the regulatory control of cynical hostility or denial and sympathetic advances of the autonomic nervous system. Results demonstrated that women who have experienced rape showed decreased frontal regulatory control capacity compared to women who have not experienced rape as evidenced in sympathetic reactivity (heart rate, electrodermal activity, and systolic blood pressure) to frontal lobe stressors. Results are discussed in terms of the extant neuropsychological literature and the implications of observed differences for women who have experienced rape type trauma.

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General Audience Abstract

Rape as a trauma type is a serious problem with the potential for severe impact on the lives of victims. Based upon past research that provides evidence for neural changes in specific brain pathways that control automatic bodily responses, the current experiment was designed to looked at how the brains of women who have experienced rape may differ from those of women who have not. By presenting women in the experiment with various external stressors and analyzing the automatic reactions of heart rate, blood pressure, and the electrical potential of the skin, it was demonstrated that women who reported a history of rape had increased difficulty controlling their physiological and emotional reactions to stress. The results support the idea that women who have experienced rape may see and experience the world differently than women who have not. The findings of the study are discussed in terms of the overall implications the observed differences may have on the lives of women who have experienced rape and future directions for improved research and interventions, including assessment and treatment, for rape as a trauma type.

Acknowledgements

First and foremost, I would like to acknowledge Dr. David Harrison, without whom I would not have had the opportunity to be at Virginia Tech. Dr. Harrison was an exceptional mentor and advisor who was unrelentingly generous with his wealth of knowledge he has gleaned over his long and productive career. Dr. Harrison supported me in my growth as a neuropsychologist and as a researcher, insisting I improve my theoretical understanding of neural systems before attempting to wade into the empirical landscape of experimentation. Prior to my time at Tech, I felt like I was not living my potential and it was Dr. Harrison who helped create a space for me to explore and learn everything I wanted. For this opportunity, I am extremely grateful and in his debt.

Beyond Dr. Harrison, others who went above and beyond to ensure my success include Dr. George Clum, always willing to extend an incredibly knowledgeable ear about any topic, and Dr. Russell Jones, with his tireless support and assurance that I keep my eye on the bigger picture. Both Dr. Clum and Dr. Jones served as faculty committee members throughout my time and I am grateful to both for seeing me forward on this path. I am also grateful to Dr. Rachel Diana who was willing to come on board my dissertation committee and for her kindness. Others I would like to acknowledge include Dr. Kelly Harrison for being willing to show up for me and counsel me at any time, and Dr. Pearl Chiu for being on my preliminary committee and for her openness in considering my somewhat overly ambitious initial dissertation proposal. I would also like to acknowledge Dr. Roseanne Foti for her support this past year in her role as the psychology department chair, as well as all the department staff, particularly Michelle Wooddell, Kim Raymond, and Ben Pfountz.

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1. Introduction

1.1: Demographics and Description of PTSD

Post-traumatic stress disorder (PTSD) is a serious neuropsychological disorder impacting approximately 3.5% of adults in the United States, with 36.6% of the cases classified as “severe” cases of PTSD (Kessler et al., 2006). Further, it is estimated that nearly 70% of adults have experienced at least one traumatic event in their lives, with up to 20% of individuals who experience a traumatic event developing Posttraumatic Stress Disorder (PTSD) and approximately 24.4 million people living with PTSD at any given time (American Psychiatric Association, 2013). With such a high prevalence and impact, PTSD has become a serious concern, both socially and economically, associated with increasing health costs and an overall general loss of function in daily activities.

Foundational to PTSD is the presentation of extreme stress conditions or trauma and the subsequent behavioral and emotional response to that trauma. Medically, to receive a diagnosis of PTSD, criterion A in the DSM-5 must be met, which functions as the diagnostic identifier that refers specifically to experiencing trauma such as the actual or threatened experience of death, serious injury, or sexual violence, either directly or vicariously (American Psychiatric Association, 2013). Subsequent criterion in the DSM 5 deals with emotional and psychological impacts of the traumatic event and can include negative thoughts or feelings, avoidance of triggers or reminders of the trauma, and a general alteration in mood and behavior.

While the specific causal mechanisms of PTSD continue to be researched, within adult populations, PTSD findings in women have indicated an incidence double that of men, (Olff, Langeland, Draijer, & Gersons, 2007), leading some to theorize that being a woman is a risk factor for PTSD. However, many findings exploring potential gender differences in both the severity and incidence of PTSD either minimize or ignore trauma type as a serious contributing factor. Increasing evidence for the type of trauma an individual is likely to experience as a mediating variable is mounting.

1.2: Trauma Type and the Statistics of Rape

When considering the potential contributions of trauma to PTSD, trauma type and the neural impact of different trauma experiences is an area in need of continued research efforts. Research has demonstrated that interpersonal trauma, along with internalizing emotions and thoughts, has been implicated in higher rates of PTSD in children and adolescents (Kahana, Feeny, Youngstrom, & Drotar, 2006). In their meta-analysis of well-established diagnostic interviews, Alisic et al. (2014) were able to determine that interpersonal trauma (such as assault) showed a dramatic increase in PTSD symptoms and diagnosis. Their research provides a compelling argument that interpersonal trauma violates basic feelings for safety and trust, resulting in greater levels of maladaptive cognitions (i.e. self-blame) and states of chronic stress, both of which have been implicated in the establishment of PTSD (Bangasser & Valentino, 2014).

It has been proposed that trauma type may contribute uniquely to PTSD, and within this context sexual assault is arguably one of the more complex and damaging interpersonal traumas of which an individual can be a victim. Evidence shows girls and women are more likely to experience sexual abuse than boys and men. In a quantitative review of 25 years of research on the sex differences in trauma and post-traumatic stress disorder, Tolin and Foa (2006) determined that adult women were more likely to experience sexual assault than men while being less likely to experience other potentially traumatic events (PTE) and that women were more likely to meet diagnostic criteria for PTSD. When sex differences in adolescents were examined, females showed higher rates of PTEs, primarily due to incidence of sexual assault. Data from 6,483 adolescents in the National Comorbidity Survey Replication Adolescent Supplement (NCS-A) confirmed that females (7.3%) are more likely than males (2.2%) to experience a lifetime PTE, with rape and sexual assault connected with the highest conditional probability of PTSD, at 39.3% and 31.3%, respectively (McLaughlin et al., 2013). In a systematic review on the prevalence of childhood sexual abuse, Barth, Bermetz, Heim, Trelle, & Tonia (2013) examined fifty five empirical studies from 2002 to 2009 from 24 countries. Their exhaustive review provided further evidence for the increased prevalence of sexual abuse experienced by girls under the age of 18. Estimates from their study showed that prevalence of sexual abuse for girls range from 8% to 31% and 3% to 17% for boys.

In adult populations, one in five women in the U.S. experience sexual assault and/or rape at some point in their life, with 91% of rape victims and sexual assault being women (Black, et al., 2011; Rennison, 2002). Given the prevalence of this type of trauma, increased research efforts into the impact of sexual assault on neurobiological systems is imperative. The current experiment aimed to provide neuropsychological evidence for the impact that rape may have on these systems. By analyzing the various neuropsychological and psychophysiological responses in individuals who have experienced rape, it was hypothesized that differences will be observed when compared to healthy controls. To create a framework for the analysis of neurophysiological differences that may result from rape, a review of pertinent neuropsychological theory is necessary.

1.3: Functional Cerebral Systems Theory

Described by Alexander Luria in 1973 (Luria, 1973; 1980; See also Harrison 2015, Ch. 4), functional cerebral systems theory captures seemingly discrete processing within neural systems for cognition, emotion, and behavior by integrating the interhemispheric connections via the corpus callosum and the intrahemispheric connections via the longitudinal tracts into a functional model for neural processing and is foundational to providing an understanding how trauma may impact neural systems. Luria provided evidence that these neural networks support a highly coordinated functional and systemic interaction between posterior sensory reception and analysis and anterior executive function and regulatory control brain regions, while allowing for communication between the cerebral hemispheres (Luria, 1973). Luria further described the brain as organized into three overarching functional units, with the brainstem structures comprising the first functional unit, the posterior regions of the brain including the temporal, parietal, and occipital lobes making up the second functional unit, and the frontal lobe providing the third functional unit. Each functional unit contributed to the processing and integration of information with increasingly complex neural formulations progressing from the second functional unit and with regulatory control or down regulation/inhibition derived from the third functional unit (frontal lobe) (Luria, 1980).

1.4: Arousal Theory

At its most basic level, the brain requires an arousal to function properly and evidence has demonstrated much of this arousal is driven from the first functional unit as proposed in functional cerebral systems theory. To this end, arousal theory postulates that diffuse projections from the mesencephalic reticular formation connect with ipsilateral higher brain structures and that these neural connections drive higher unit activation or arousal (Isaac & DeVito, 1958; Moruzzi & Magoun, 1949). Prior research has supported this theory by demonstrating a complex bidirectional relationship for overall system arousal via the mesencephalic reticular formation and polymodal association areas within the prefrontal lobe. Via inhibitory and excitatory networks, the prefrontal lobe and mesencephalic reticular formation work to differentially provide inhibition or activation of the nucleus reticularis, which subsequently inhibits thalamic relays. The degree of inhibition or excitation of thalamic relays translate directly into increased arousal of sensory cortices and subsequent association cortices. Ultimately, this integrated and functional network provides general activation of cerebral system through the thalamus and posterior neural systems, with the prefrontal cortex exerting ipsilateral regulation over the various posterior systems and the RAS (Bandler & Shipley, 1994; See Harrison, 2015; Heilman & Valenstein, 2010; Jasper, 1949). Lesions within this system can result in arousal disorders with symptoms that range from coma to mildly dysarthric speech (Harrison, 2015). Given the role arousal plays on overall alertness, responsiveness, cognition, and emotional response, this process for neural stimulation is imperative for a discussion exploring the potential impact of trauma on neural systems.

1.5: Valence Theory

Looking at the complexity of human behavior, hemispheric differences based on primarily lateralized functioning begins to emerge and provides important context when exploring environmental insults such as trauma. Valence theory proposes that each hemisphere preferentially processes a general emotionally valenced response with positively valenced emotions represented in the left hemisphere, whereas negatively valenced emotions and relatively intense emotions are more represented in the right hemisphere (Borod, 2000; Demaree, Everhart, Youngstrom, & Harrison, 2005; See also Harrison, 2015, Chapter 20; Heilman, Bowers, & Valenstein, 1993). It has been further shown that sympathetic responses tend to be driven preferentially by the right hemisphere, while parasympathetic response have their origin in the left hemisphere (Foster, Drago, Ferguson, & Harrison, 2008; Foster, et al., 2011; Hoffman & Rasmussen, 1953; Heilman, Schwartz, & Watson, 1978; Oppenheimer & Cachetto, 1990; Oppenheimer et al., 1992; Wittling, 1990; 1995; Wittling & Gentel, 1999; Zamrini et al., 1990; See also Harrison, 2015, Chapter 26). This supposition follows with the previously described role of right hemisphere activation in intense, negative emotions like fear and anger as many intense emotions are accompanied with physiological responses such as increased heart rate, pupil dilation, and sweating via sympathetic activation.

1.6: Capacity Theory

While the previously outlined theories provide a basis for the neural systems and subsequent behavioral responses that may accompany traumatic experiences, a final theory is necessary to explain the potential for systemic neural changes. Capacity theory postulates that the brain relies on the utilization of finite resources, particularly glucose and oxygen, for general neural functioning (Carmona, Holland, & Harrison, 2009; Comer, Harrison, & Harrison, 2015; Klineburger & Harrison, 2015; Walters, Harrison, Campbell, & Harrison, 2016; Walters, Harrison, DeVore, & Harrison, 2016; Williamson, & Harrison, 2003). Over-stress or exertion of a specific brain region can result in consumption of available resources to exhaustion driving intratoxic effects established at the mitochondrial level. Mitochondrial shape and function changes in response to stress and increased energy demands moderate neural system resource allocation via mobilization of glucocorticoids and catecholamine hormones (Picard, McEwen, Epel, & Sandi, 2018).

Analogous to over-taxation of a muscle, the brain will work to avoid becoming damaged if forced into prolonged activation. Highly stressful events, such as rape, may exceed the regulatory capacity limitations of the frontal lobe with the potential for injury to this system. If overexertion of the frontal region persists towards chronic exhaustion, regional oxidation can lead to excitotoxicity through prolonged release of otherwise normal neurochemicals, such as glutamate (Averill et al., 2016; Cortese & Phan, 2005; Popoli, Yan, McEwen, & Sanacora, 2012). To avoid long-term damage, the frontal lobe deactivates which allows for an unbridling of sensory and emotional analyzers in the second functional unit (Tucker & Williamson, 1984). Capacity theory provides a demonstrable neurological explanation for the observed behaviors associated with extreme stress, such as violent anger or the freeze response, as well as implications for observed long-term neural changes.

1.7: The Right Hemisphere and Intense Emotional Experience

Through integration of the presented neuropsychology theory, new explanations and hypothesis can be generated to help improve understanding of stressful events and trauma such as rape. Integral to the presentation of emotion is neural arousal. Through continued examination of arousal, it was determined that arousal did not appear to be equally distributed between the left and right hemispheres of the brain. The neuropsychologist Kenneth Heilman, along with Thomas Van Den Abell (1980), noticed that patients with damage to the right temporal/parietal region responded with decreased emotion compared to patients with left hemispheric damage. Similarly, Konigsmark, Abdullah, & French (1958) and others (see Moruzzi & Magoun, 1949) had previously noted a unidirectional relationship between prolonged ipsilateral cortical activation and electrical stimulation of the right reticular mesencephalic reticular formation. This cortical persistence was less pronounced in similar stimulation of the left reticular formation. These findings further implicate the right hemisphere in the propagation and maintenance of increased states of arousal, including emotional intensity.

Following the evidence for the differential role of the right hemisphere in high arousal states, sympathetic initiation and propagation processes are lateralized predominantly to the right brain (Levy & Martin, 1984; Wittling, Block, Genzel, & Schweiger, 1998). Presentation of an emotionally salient film exclusively to the right hemisphere has been shown to significantly increase both systolic and diastolic pressure compared to presentation to the left hemisphere (Wittling & Pflüger, 1990). More recent research has supported the role of the right hemisphere in activation of sympathetic tone (Comer, DeVore, Harrison, & Harrison, 2017; Comer, Harrison, & Harrison, 2015; Holland, Mitchell, Steele, Bunting, & Harrison, 2017; Holland, Newton, Hinson, Hardin, Coe, & Harrison, 2014; Walters, Harrison, DeVore, & Harrison, 2016) and glucose mobilization as a fundamental neural resource (DeVore & Harrison 2017; Walters, Harrison, Campbell, & Harrison, 2016) Research in high-hostile individuals has shown decreased right frontal regulation over posterior emotional activation, pain intensity, and blood glucose mobilization in response to emotionally salient stimuli, further implicating the preferential lateralization of these processes to the right hemisphere (Mitchell & Harrison, 2010; Walters, Harrison, Campbell, & Harrison, 2016; Walters, Harrison, DeVore, & Harrison, 2016). Given the overall dominance of the right hemisphere for increased arousal and sympathetic tone, it would logically follow that emotional responses, particularly intense emotional responses, would rely heavily on right hemispheric activation, as demonstrated by early neuropsychological research (Borod, 2000, Buck, 1984, Tucker & Williamson, 1984).

While the evidence for the role of the right hemisphere in emotion appears to be well established (Babinski, 1914; Brown, 1952; Heilman & Bowers, 1990), it is important to consider the general properties of each functional unit underlying emotion. While posterior damage to the right hemisphere may result in decreased arousal and diminished emotional intensity, (Heilman et al., 1993) damage to the frontal lobe has been shown to result in hyperarousal and decreased emotional regulation (e.g. McCullagh, Moore, Gawel, & Feinstein, 1999; Agustin-Pavonetal, 2012). Given the role of the frontal lobe in the regulatory control of inhibition of the posterior emotional analyzers, heightened sympathetic arousal and negatively valenced emotional response is expected. This has been demonstrated in patients with right frontal damage as well as in research with healthy individuals (See Carmona, Holland, & Harrison, 2009; Foster et al., 2008, Isaac & DeVito, 1958; Shenal, Harrison, & Demaree, 2003).

Emotional provocation (Borod et al., 1998), the elements of emotional prosody in speech (Borod et al, 2000; Bowers, Bauer, & Heilman, 1993)**,** and the perception of emotionally charged facial expressions (Herridge, Harrison, Mollet, & Shenal, 2004) have all been demonstrated as right hemisphere processes. As mentioned previously, research into individuals who express high levels of cynical hostility and aggression has shown that people with these traits demonstrate increased right hemispheric activation. This activation is associated with decreased right frontal regulatory capacity and heightened emotional response to not only salient emotional stimuli, but to a generally neutral stimulus as well (Walters, Harrison, DeVore, & Harrison, 2016). The implications of this research for trauma experience and the right hemisphere's specialized role in both the processing of external emotional stimuli and the internal experience of intense and negatively valenced emotion cannot be ignored.

Looking at treatment, if trauma experience such as rape results in changes to neural systems, targeted interventions can also be considered. Consider the right hemispheric specialization for emotional experience and expression with verbal fluency lateralized to the left hemisphere. Treatment relying solely upon verbal or linguistic processing may be inadequate or superficial at fully accessing the underlying neural systems associated with intense and negative emotional concerns. Within the current context of the neural impact of trauma type on varying neural systems, including the somatosensory system, sympathetic response system, frontal regulatory system, and the various tertiary association areas impacted by a salient emotional trauma, treatment seeking to get at emotional impact utilizing purely logical and linguistic analyzers may be insufficient. Perhaps this is the reason for the somewhat curious effectiveness of unorthodox treatment interventions, while purely verbal interventions are left wanting in PTSD. If a psychological treatment such as Cognitive Behavioral Treatment (CBT) relies solely upon linguistic processing, the treatment would be limited in its effectiveness simply due to an inability to directly access the right cerebral system.

1.8: Capacity Theory and Neural Change Due to Trauma

Two elements define capacity theory: 1. Functional cerebral systems rely on finite resources. Expenditure of those resources results in diminished capacity for general function. Within this framework, glucose and oxygen utilization fits well. 2. Neural systems may systematically and dramatically decrease function to avoid neural damage due to over utilization.

These various constructs will be discussed in greater detail to provide clarity regarding proposed neural changes that may result from rape.

As previously described, the brain is similar to any other organ in the body with protective measures to keep itself safe from over exertion. The brain consistently works to maintain a state of relative homeostatic preparation to respond to external stimuli (Merrill & Jonakait, 1995), such that the majority of energy the human body uses is dedicated to the brain (Kolb, Whishaw, & Teskey, 2015). Trauma, by its very nature, demands the allocation of a vast amount of neural resources such that the brain may not be fully equipped to respond without resulting in neural toxicity and damage. Consider a situation of physical abuse: not only is the brain having to contend with the fear and stress produced by the trauma, but also the somatosensory activation resulting from the physical impact of the trauma on the body. Added to this potent neural stimulus are subjective attempts at comprehending the situation, determining how to stop or control the situation, and the drive to survive.

In trauma situations, emotion becomes a process by which deep neurological structures respond to external and internal signals to initiate physiological responses. As recruitment through deep neural structures continues, higher cortical regions within the secondary association areas begin to incorporate and translate the sensory information, constructing elaborate cognitive representations for analysis and processing within the third functional unit. In relatively mild emotional representations, frontal regulator control can exert functional regulation over posterior neural regions and deeper neural structures, including the brainstem. However, if the external stress or emotional stimulus is highly salient or prolonged, the capacity of the frontal lobe to down regulate these same regions is diminished. Once exhausted, the prefrontal cortex may temporarily become inactive, allowing an uncontrolled activation of deep neurological structures.

Prolonged trauma has also been implicated with changes in the prefrontal cortex, amygdala, hippocampus, and interconnectivity between these regions and brain stem nuclei. These changes are seen at the gross structural level and at the microscopic chemical level (McEwen, Nasca, & Gray, 2016; Pitman et al., 2012).

1.9: A Systematic and Functional Theory of the Neural Impact of Rape

Rape includes various severe experiences such as loss of control, physical restraint, verbal abuse, and risk of pain and death. Rape is also an interpersonal trauma, typically perpetrated by someone known by the victim (Lisak, Gardinier, Nicksa, & Cote, 2010). From a neuropsychological perspective, rape as a trauma type requires the dedication of many functionally distinct brain regions in order to process. Fundamental to the cascade of neurological events associated with processing this type of trauma accommodation is the response of the fear system, including recruitment of the amygdala, prefrontal regulatory systems, hippocampal processing, and sympathetic response associated with the fight or flight response (Suchy, 2011). Further taxation of neural systems is associated with the direct insult, often times violent, to the core line (i.e. genitalia, trunk, head) of the body that rape victims are often subject to. Evidence shows that such experiences induce increased activation of the somatosensory cortex with heightened recruitment of deep cortical structures, such as the amygdala, thalamus, and cingulate cortex, associated with intense emotional response and the insular cortex (Cazala, Vienney, & Stoleru, 2015). Rape floods neural systems with multimodal stimuli that may overwhelm neural resource allocations past capacity and the following proposed mechanism of neural insult may result.

Proliferation of a heightened arousal state due to rape diffuses through the thalamus where the various sensations, including vision and audition, are sent to their respective primary projection areas before becoming integrated for associative analysis through the secondary and ultimately multimodal analysis in the tertiary association areas. Subsequently, the pathway connects the sensory and emotional experience of the event with the frontal regions via the longitudinal tract (collectively). These same arousal signals cause increased activation of the hippocampus and amygdala, which begin to create emotional memories of the event (Borod, 2000). Increased amygdaloid kindling can result in heightened arousal, driving intense subjective emotional experience of the situation (Harrison, 2015).

Ventral to the thalamus, the hypothalamus responds to the threat through activation of the HPA axis, to release cortisol and to further prepare the organism for action. While these various structural processes compete for neural resources, the prefrontal cortex attempts down regulate the intensity of the aroused systems. However, due to the emotional force of the experience, the frontal lobe’s capacity to regulate the neural system is potentially exceeded, allowing for unregulated excitation of the emotional processes. This unbridling and over excitation of frontal systems may result in a flood of synaptic glutamate. Without appropriate regulation of glutamatergic activity, neurotoxicity can occur, resulting in dendritic atrophy and structural changes (Gao et al., 2014). If these same emotional systems remain in a chronically stressed state, further neural damage is possible. Behaviorally, these neural responses translate into fighting against the assailant, the experience of intense bodily sensations, extreme emotional reactivity, and the potential for freeze behaviors, which have been correlated with dissociation symptoms (Kaplow, Hall, Koenen, Dodge, & Amaya-Jackson, 2008). Drawing from these neurological elements and Capacity Theory, it is hypothetically probable that rape, due to the emotional intensity associated with the type of trauma, is more likely to result in PTSD than other types of trauma.

To provide evidence for the proposed neurophysiological changes that rape may cause, the current experiment sought to give preliminary evidence to support a neuropsychological definition of the impact rape has on the brain. Through synthesis of the review of the various neuropsychological theories of emotion, particularly capacity theory, it is logical to surmise that neural changes due to traumatic experiences may be the result of an overextension of neural resources and the inability of the brain to fully respond to a highly salient and impactful event like rape. This diminished response is associated with the overload of neural systems from multiple stressors all vying for regulatory control of the frontal lobes. If capacity of the frontal region is exceeded to such an extent that it allows for unregulated glutamate release, neural damage may occur. Further consequences of frontal collapse also include an unbridling of secondary functional processing, which can include emotional, physiological, and sensory release. Translating this theory into behavior responses allows for an explanation of many of the reactions seen in individuals subjugated to trauma.

1.10: Behavioral Correlates of Rape

To examine the proposed decreased frontal regulatory control that may result from rape, it is necessary to build upon research efforts that look at similar constructs within other emotional contexts. To this degree, there is an abundance of research looking at lower frontal regulatory control in cynical high hostile individuals (Carmona, Holland, & Harrison, 2009; Comer, Harrison, & Harrison, 2015; Holland, Carmona, & Harrison, 2012; Holland, Mitchell, Steele, Bunting, & Harrison, 2017). Within the previously described theoretical model of the right hemisphere, high hostile individuals have reliably demonstrated decreased right hemispheric regulation associated with decreased right frontal lobe control over sympathetic and emotional processing. To translate the hostility research into the realm of trauma and rape, the current experiment utilized physiological measures and frontal lobe stressors used with high hostile individuals. To this end, it was hypothesized that women who have experienced rape will demonstrate similar neurophysiological and behavioral responses as those seen in high hostile individuals. Specifically, it was proposed that these differences would be demonstrated in comparison to a control group of women who have not experienced rape.

2. Method

2.1 Hypotheses

General Hypotheses

1) It was hypothesized that there would be arousal response differences between women who have experienced rape and women who have not.
2) It was hypothesized that women who have experienced rape would demonstrate decreased right frontal capacity compared to women who have not experienced rape.

Descriptive Measure Hypotheses: Hostility and Denial, Depression and Anxiety

1) It was hypothesized that women who have experienced rape would score higher on measures of hostility and denial compared to women who have not experienced rape.
2) It was hypothesized that women who have experienced rape would score higher on measures of anxiety and depression than women who have not experienced rape.

Physiological Hypotheses

1) It was hypothesized that women who have experienced rape would demonstrate decreased frontal regulatory control to figural fluency stressors resulting in increased sympathetic response as recorded using heart rate, electrodermal activity, and systolic blood pressure.
2) It was further hypothesized that women who have experienced rape would demonstrate decreased frontal regulatory control to the cold pressor stressor resulting in increased sympathetic response as recorded using heart rate, electrodermal activity, and systolic blood pressure.

Behavioral Hypothesis

1) It was hypothesized that women who have experienced rape would have lower scores on measures of design fluency using the RFFT compared to women who have not experienced rape.
2) It was hypothesized that women who have experienced rape would have lower scores on measures of verbal fluency using the COWAT compared to women who have not experienced rape.

2.2: Subjects

Subjects invited to participate in the experiment were right handed women, ranging in age from 18 to 28 years. They were recruited from a major university population. Exclusion criteria included left handedness, a history of severe neurological disorders, and current intoxication. Women who met criteria for inclusion in the experiment were separated into two groups; one group consisting of women who reported a history of experienced rape (Trauma - Tr) and the other group consisting of women who reported no history of experienced rape (No Trauma - NTr). For the purposes of this experiment, rape is defined according to VA state laws as “sexual intercourse against a person’s will by force, threat, intimidation, or through the use of mental incapacity or physical helplessness” (Virginia Code 18.2-61) and a history of rape experience was determined via self-report using the Revised Sexual Experiences Survey (R-SES) (Koss et al., 2007). Subjects were provided the Informed Consent Form (See Appendix A) for the experiment and briefed on the procedure. In order to screen for exclusion criteria, individuals were asked to complete the Behavioral Neuroscience Laboratory (BNL) Medical History

Questionnaire (See Appendix B). This questionnaire provided information relevant to medical concerns, medication history, and substance use history.

2.3: Apparatus & Questionnaires

Medical History Questionnaire

The Medical History Questionnaire is the standard questionnaire for research in the Behavioral Neuroscience Lab (BNL), which consists of questions designed to determine exclusion from the experiment based upon preexisting conditions (e.g., Mitchell & Harrison, 2010). Standard exclusion criteria include serious psychiatric disorders, a history of severe neurological concerns, and severe head trauma.

Revised Sexual Experiences Survey (R-SES)

The R-SES (Koss et al., 2007) is a 12-item dichotomous yes-no survey response questionnaire that assesses sexual victimization and experience with sexual assault. The questionnaire is separated into three sections that cover varying tactics for sexual assault perpetration (verbal tactics, physical tactics, and incapacitation) with four questions in each section that advance in severity, ranging from fondling to forced penetration. Scoring on the R-SES places heightened weight on the more severe forms of sexual assault on a 1 to 4-point scale within each module of questions (For a maximum score of 12). Subjects 3 or higher on the R-SES were placed in the trauma (Tr) group. A dichotomous yes-no follow-up questions was included on the R-SES addressing restraint use during reported sexual assault to identified subjects for analysis within the Restraint (Rt) group. A second dichotomous yes-no follow-up question was also included asking about sexual assault occurrence greater than one year for identification of women within the History (Ht) group.

Beck Anxiety Inventory (BAI): The BAI (Beck & Steer, 1990; Bardhoshi, Duncan, & Erford, 2016) is a 21-item Likert scale self-report instrument designed to assess for symptoms of various anxiety disorders experienced within the past week. The BAI is the gold standard self-report instrument for the assessment of anxiety (Fydrich, Dowdall, & Chambless, 1992). The BAI was used to screen for a variety of anxiety-related symptoms experienced by the subject within the past month.

Beck Depression Inventory-II (BDI-II): The BDI-II (Beck, Steer, & Brown, 1996) is a 21-item Likert scale self-report instrument designed to assess for symptoms of depression. The BDI-II has demonstrated high internal consistency and concurrent validity for the measurement of depression, particularly in college-age samples (Storch, Roberti, & Roth, 2004). The BDI-II was used to screen for a variety of depression related symptoms experienced by the subject within the past two weeks.

Cook-Medley Hostility Scale (CMHS): The CMHS is a 50-item true/false self-report questionnaire designed to assess for the presence of cynical hostility, anger, and resentment. The CMHS was derived from the Minnesota Multiphasic Personality Inventory (see Smith & Frohm, 1985) and has been shown to be a reliable and valid measure of state hostility (Demaree & Harrison, 1997; Demaree, Harrison, & Rhodes, 2000; Smith & Frohm, 1985). The CMHS has demonstrated high convergent and discriminant validity with regard to physiologic measures (Raikkonen, Matthews, Flory, & Owens, 1999). Moreover, high and low levels of cynical hostility recorded on the CMHS have consistently predicted neuropsychological variations and brain asymmetry across visual (Foster et al., 2008), auditory (Klineburger & Harrison, 2015), somatosensory (Mitchell & Harrison, 2009; Mitchell & Harrison, 2010), motor (Holland, Newton, Hinson, Hardin, Coe, & Harrison, 2014), and premotor (Cox & Harrison, 2008;

Harrison, 2015) brain regions. The current project used the measure to identify subjects scoring above 29 as high-hostile (Williamson & Harrison, 2003). These cutoffs were established by prior research in the Behavioral Neuroscience Laboratory (BNL). Subjects were grouped as high hostiles to explore the potential connection between the experience of rape and the presence of hostility. Reliable findings along this dimension will provide utility in the neuropsychological underpinnings of rape with predictions established within capacity theory (Harrison, 2015; Walters, Harrison, Campbell, & Harrison, 2016; Holland, Carmona, & Harrison, 2012; Walters, Harrison, DeVore, & Harrison, 2016).

Marlowe-Crowne Social Desirability Scale (MCDS): Due to evidence that hostility in women may present more readily as defensive denial (Emerson & Harrison, 1990), the MCDS (Crowne & Marlowe, 1960), a 33-item true/false dichotomous self-report measure, was used in conjunction with the CMHS to determine the presence of high emotional reactivity associated with denial (Jamner & Schwartz, 1986). Women scoring 17 and above were classified in the high denial group to explore the potential connection between the experience of rape and the presence of denial. Scoring cutoffs were selected for consistency with prior BNL research (Emerson & Harrison, 1990) and with extension to the broader literature reviewed.

Coren, Porac, and Duncan Laterality Questionnaire (CPD): The CPD (Coren, Porac, & Duncan, 1979; See Appendix D) is a 13 item self-report questionnaire designed to assess lateral preferences for the sensory modalities (visual, auditory) and for bodily initiation and movement. Items are scored as +1, -1, or 0 for “right”, “left”, or “both” with a range of scores from -13 to +13. Right lateral preference, as indicated by a score greater than or equal to +6, was required for participation in the project. This cutoff was selected for consistency with the relevant line of research on cerebral laterality from the our laboratory (e.g. Cox, DeVore, Harrison, & Harrison, 2017; Demaree, Harrison, & Rhodes, 2000; Higgins, Harrison, Mitchell, & Harrison, 2015).

2.4: Physiologic Variables

Physiologic: A Biopac® Systems Inc. MP150 SW Data Acquisition Platform with a UIM100C interface module was used to record heart rate (HR), Electrodermal Activity (EDA), and systolic blood pressure (SBP). Blood pressure data were recorded using a NBIP 100D Continuous Non-Invasive Arterial Pressure (CNAP 500) monitor with associated Non-Invasive Blood Pressure (NBP) oscillometric arm cuffs. The systolic measurement range for the NBP cuff is 40 – 260 mmHg for adults with an initial inflation pressure of 160 mmHg and sampling rate of 100 Hz. Bladder inflation time for the NBP cuff is 75 seconds with a maximum measuring time of 130 seconds for adults. Automatic bladder deflation occurs after 180 seconds and clinical accuracy of the NPB cuff monitor is +- 3 mmHg. To ensure accurate fit of the arm cuff, arm circumference was measured to determine appropriate arm cuff size. In accordance with the CNAP Monitor operator’s manual, the arm cuff was placed 1.5 cm above the antecubital space with the cuff indicator over the brachial artery (Biopac® Systems, Inc., 2015). Blood pressure readings were obtained within 10 seconds pre and post for each condition administered during the experiment.

2.5: Stressors and Behavioral Variables

Verbal Fluency

The *Controlled Oral Word Association Test* (COWAT) is a neuropsychological measure designed to assess verbal fluency and is a subtest of the Multilingual Aphasia

Examination (MAE; Benton, Hamsher, & Sivan, 1994). The COWAT consists of three trials using three letter sets to assess verbal fluency by giving subjects one minute to name as many words as possible beginning with an assigned letter (see Strauss, Sherman, & Spreen, 2006 and Benton, Hamsher, Rey, & Sivan, 1994 for specific administration instructions). For the current experiment, F, S, T was used due to the tendency of these letters to produce an equal number of responses (Everhart & Harrison, 2002; Williamson & Harrison, 2003). Final score is determined by the sum of all acceptable words across the three trials. Consistent with previous research on hemispheric specialization for verbal fluency, the COWAT has been shown to predominantly be a left frontal stressor due to the premotor specialization of the left cerebral hemisphere for verbal fluency and generativity (Ruff, Light, Parker, & Levin, 1997; Tucha, Smely, & Lange, 1999; Walters, Harrison, Campbell, & Harrison, 2016).

Nonverbal Fluency

The *Ruff Figural Fluency Test* (RFFT) is a neuropsychological measure developed to assess figural fluency (Ruff, Light, & Evans, 1987). Nonverbal figural fluency has been demonstrated to be predominantly related to integrity of the right premotor region with right frontal lobe lesions resulting in impaired performance on the RFFT (Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001). Performance on the RFFT has been shown to function preferentially as a right frontal stressor (Foster, Williamson, & Harrison, 2005, Holland et al., 2014; Ruff, Allen, Farrow, Niemann, & Wylie, 1994). The RFFT has demonstrated good test-retest reliability (Ruff et al., 1987) and interrater reliability (Berning, Weed, & Aloia, 1998; Ross, 2014). The original measure consists of five trials with each trial containing a different 35 dot matrix arranged in a 5 X 7 array. To maintain consistency with the COWAT, the current experiment only used the first three trials of the RFFT (Walters, Harrison, Campbell, & Harrison, 2016**)**. For each trial, subjects were given one minute to produce as many unique designs as possible by connecting two or more dots. The RFFT was scored by adding the number of unique designs completed by the subject. As a secondary measure, perseverative errors, defined as any repetition of a previous design within the subject's responses, were also recorded and compared as an indication of performance change associated with increase cognitive stress.

Physiological Stressor

The *Cold Pressor* (CP) is a standard clinical cardiovascular and pain stressor designed to elicit responses in SBP, EDA, and HR reactivity (e.g., Demaree, Harrison, & Rhodes, 2000; Hines & Brown, 1936). The cold pressor stress test consists of subjects placing their hand in an ice water bath (measured at 0-3 degrees Celsius) to just above the wrist radiocarpal joint and holding it in place for a duration of 45 seconds. Water temperature was maintained at 0-3 degrees Celsius and monitored by the use of a calibrated H-B Instrument B60303 Glass Thermometer.

2.6: Procedure

Subjects were recruited from the undergraduate population at Virginia Tech. The experiment was advertised on the Psychology Department SONA system with a brief description of the research project and instructions to sign up for participation (See appendix E). Final approval for this research experiment came through the Virginia Polytechnic Institute and State University Institutional Review Board and adhered to all pertinent regulatory rules and restrictions. All elements of the project were administered by female researchers, fully trained in the procedural application, including equipment operations and application, as well as data acquisition. For purposes of procedural flow, the experiment was broken down into 2 phases.

Experimental Phase 1:

Upon signing up for the experiment via the online SONA system, subjects were invited to complete the MHQ, BAI, BDI-II, CMHS, MCDS, and the CPD prior to arriving at the lab. Individual scores were collected and entered into a deidentified excel spread sheet for analysis. Subjects could choose to not complete the online questionnaires and incomplete forms were not recorded. If a subject completed the online forms and met inclusion criteria for the study, they were sent an invitation email via SONA to participate in the in-lab portion of the study. Participants were awarded 0.5 points of SONA credit for completing the online questionnaires, regardless of inclusion in the in-lab portion.

Experimental Phase 2

If subjects chose to participate in the in-lab portion, they were provided the informed consent for the experiment to review and sign upon arrival at the lab (Appendix A). Subjects were debriefed and dismissed should they meet any of the specific exclusionary criteria or choose not to continue participation. Prorated SONA credit or cash compensation, as indicated in the informed consent and in accordance with University policy, was awarded to those subjects who were deemed ineligible to continue participation in the experiment. All subjects choosing to continue with the experiment completed the R-SES and a second MHQ to assess for any changes in their health. Subsequent grouping for data analysis was based upon the cutoff scores on the R-SES. Subjects were then allowed to ask any questions and were provided with a list of community mental health resources within the area (see appendix F).

Following completion of the questionnaires, eligible subjects were seated comfortably in front of a table with the fluency tests (Ruff Figural Fluency Test (Modified) and Controlled Oral Word Association Test) on it. Arm circumference was measured and appropriately-sized arm cuffs selected. The blood pressure cuff was placed 1.5 cm above the antecubital space of the left arm and secured. After attaching the blood pressure cuff, researchers attached Biopac® Systems General Purpose Electrodes to the right wrist above the radial artery, as well as the left and right ankle of participants. Biopac® shielded lead set for electrocardiogram acquisition were connected to the electrodes following standard Lead II arrangement of the Einthoven's Triangle to obtain heart rate (Conover, 2002). Electrodermal activity was acquired via Biopac® EDA electrodes and connected shielded lead set attached to the right pointer and middle fingers. Once the biophysiological equipment was attached, the subject was instructed to stare at a white cross on a dark background for a baseline habituation period of 3 minutes. Heart rate (HR), electrodermal activity (EDA), and systolic blood pressure (SBP), were recorded continuously throughout the experiment.

Subjects were then instructed on the first fluency stressor/behavior test (RFFT or COWAT) and asked to completed the measure, with physiological data recorded. The order of the fluency tests was administered in a counterbalance fashion. Once the first test was completed, HR, EDA, and SBP were recorded and subjects were asked to sit for 90 seconds to obtain a recovery baseline. Upon completion of the baseline period, physiological data was obtained and the alternate cognitive stressor test was then explained and completed. Upon completion of the second test, another reading was taken and subjects were asked to remain seated for another 90 seconds.

After the third 90 second resting baseline period subjects were asked to place their left hand in the cold pressor to one inch above the wrist. They were instructed to hold their hand in the ice bath for 45-seconds. Physiological data was again recorded. Once the cold pressor was completed, all biophysiological equipment was removed from the subject and they received confirmation of participation and payment (or SONA credit if requested). The experiment took approximately 60 minutes to compete.

3. Results

Statistical analysis was completed using SAS® Enterprise guide 6.1 Software (Copyright © 2014 SAS Institute Inc.) for Windows 10. A total of 53 women were recruited for participation in the study with 6 subjects not meeting the inclusion criteria for handedness and health concerns, resulting in a final N = 47. Significant differences across variables were determined using various mean comparisons and descriptive data were analyzed resulting in a normal distribution. Selection criteria from the subject sample for the primary grouping variable (Tr vs NTr) resulted in an unequal sample size with N = 20 for the Tr group and N = 27 for the NTr group. Reliability testing was administered by analysis to ensure that the assumptions of homogeneity of variance and sphericity were not violated. Secondary analyses with group separation by a history of reported restraint (Rt) versus no restraint (NRt) and a history of sexual assault greater than one year (Ht) versus no history of sexual asault (NHt) also resulted in unequal sample sizes, with Rt (N = 5) versus no NRt (N = 42) and Ht (N = 27) versus NHt (N = 20).

3.1: Self-Report Analyses

In order to test the hypothesis regarding increased hostility and denial in women in the Tr group, separate analyses of scores on the CMHS and MCDS were conducted using one-way between subjects analysis of variance (ANOVA) with main effects of outcome scores on the CMHS and MCDS compared by group, (Tr or NTr). The Levene test confirmed that homogeneity of variance was not violated. The results indicated no statistically significant differences by group for either the CMHS or MCDS. Secondary group analyses comparing restraint with no restrain and history with no history were also not significant.

In order to test the hypothesis that women who reported a history of sexual assault would score higher on the BDI and BAI, a one-way between subjects ANOVA was completed comparing the mean scores of the BAI by group. A second one-way between subjects ANOVA was completed for the BDI by group. The Levene test for homogeneity of variance indicated violations of this assumption occurred for the analysis of both the BAI and BDI. To account for this violation, reported values were derived using the Welch's ANOVA test. For scores on the BAI, differences between the Tr group and NTr group approached significance (F (1, 46) = 3.18, *p* = .085) with women in the Tr group reporting higher scores of anxiety (Figure 1). Higher scores on the BDI from women in the Tr group were also reported, but these comparisons were not significant (Figure 2).

Secondary analyses exploring the potential differences between women in the Rt group and women in the NRt group showed that women who experienced physical restraint scored significantly higher on both the BDI (F (1, 46) = 7.21, *p* = .01) (Figure 3) and the BAI (F (1, 46) = 21.56, *p* < .001) (Figure 4). Also, women in the Ht group showed significantly higher scores on the BAI (F (1, 46) = 4.59, *p* = .038) (Figure 5), with scores on the BDI approaching significance (Figure 6).

3.2: Physiologic Response Analyses

To test the hypothesis that women in the Tr group would show increased sympathetic reactivity when confronted with traditional frontal lobe stressors (verbal figural, figural fluency, cold pressor), a 3-factor mixed design ANOVA was used, with fixed effects of Group (two levels: Tr and NTr) and with repeated measures of Condition (two levels: pre vs. post condition) by Stressor (three levels: COWAT, RFFT, and CP) by subject for each of the dependent physiological variables (HR, SBP, EDA). Prior to analysis and in accordance with accepted best practices, all physiological data were inspected for artifacts and cleaned. The assumption of sphericity was met across all variables with residual maximum likelihood used as the estimation method. Post-hoc pairwise comparisons were performed using Tukey's HSD to control for experimentwise error rate.

Results of the mixed design ANOVA for the dependent variable of HR indicated an interaction effect between Condition and Stressor (F (2, 74) = 5.70, $p = .005$), demonstrating reliable heart rate differences between pre and post conditions for each stressor. A significant Group x Condition interaction was also observed at the Tr group level by Condition (F (1, 43) = 7.79, $p = .008$) with subjects in the Tr group showing significantly heightened heart rate response from prestress to post stress conditions (Figure 7). The Tr Group x Stressor interaction approached significance (F (2, 86) = 2.64, $p = .077$) with women in the Tr group showing heightened heart rate responses to the CP compared to the COWAT and the RFFT. Main effects were reliable for Condition (F (1, 43) = 14.39, $p < .001$) indicating overall reliably increased heart rate across the pre compared to the post stress condition. Main effects were also reliable for Stressor (F (2, 86) = 11.73, $p < .001$) with significant heart rate differences shown between the COWAT, RFFT, and CP.

Two additional mixed design ANOVAs for HR were completed to explore group differences for Rt versus NRt and Ht versus NHt. Results indicated statistically reliable differences for Stressor as a function of Rt (F (2, 86) = 6.42, $p = .003$), where women in the Rt group showed overall significantly heightened heart rate and heart rate reactivity to each stressor compared to women in the Rt group (Figure 8). Similar interaction effects were seen for Stressor as a function of Ht (F (2, 86) = 5.69, $p = .005$) (Figure 9). To determine if the observed differences for the Rt group was specifically associated with the experience of restraint, and follow-up mixed design ANOVA was completed comparing the Rt group to women who reported rape, but no restraint. The results indicated statistically significant interactions for Condition x Stressor (F (2, 54) = 9.00, $p < .001$) and Stressor x Group (F (2, 54) = 9.33, $p < .001$), with women in the restraint group showing significantly higher HR responses to the RFFT and cold presser Stressors.

To account for the potential moderating effect remote history of sexual assault (Ht) may play on the grouping variable of Tr, a follow-up mixed design ANOVA was completed with subjects providing confirmation of Ht, but not Rt, removed from the comparison group. The resulting sample size was N = 35, with the sample of TrH = 21 and NTrH = 14 subjects. This analysis resulted in a significant interaction effect for the previously non-significant stressor variable as a function of TrH group (F (2, 62) = 4.42, $p = .016$). The interaction effects of Stressor as a function of Rt (F (2, 62) = 15.87, $p < .001$) and Stressor as a function Ht (F (2, 62) = 11.00, $p < .001$) were also maintained controlling for Ht.

Results of the mixed design ANOVA for the dependent variable of SBP were similar to those of HR with a significant interaction of Condition as a function of Tr (F (1, 43) = 10.06, $p = .003$) with Least Squares Means showing that only women in the Tr group demonstrated significantly different SBP between baseline and condition (Figure 10). A significant interaction effect was also found for Stressor as a function of Tr with women in the Tr group showing higher SBP, particularly to the cold pressor stressor (Figure 11). The main effects of Condition (F (1, 43) = 16.73, $p < .001$) and Stressor (F (2, 86) = 3.62, $p = .031$) were both significant. The significant interaction effect of Condition x Stressor (F (2, 74) = 3.00, $p = .056$) approached significance.

Secondary mixed design ANOVA for SBP looking at group differences for Rt showed a significant interaction for Stressor x Restraint (F (2, 86) = 5.45, *p* = .006), with women in the Rt group showing a significantly lower SBP response to the verbal fluency stressor (COWAT) with heighten SBP to the cold pressor stressor (Figure 12). The Condition x History interaction was significant (F (1, 43) = 4.79, *p* = .034) with women in both the Ht and NHt groups showing reliable changes in SBP prestress versus post stress. However, women in the Ht group displayed higher overall SBP for both pre and post stress conditions (Figure 13).

Results of the mixed design ANOVA for the dependent variable of EDA indicated significant differences for the main effect of Trauma group (F (1, 43) = 5.71, *p* = .021) with women in the Tr group showing significantly higher EDA phasic events (Figure 14). Post-hoc analyses revealed that women in the Tr group showed significantly heightened arousal as indicated by phasic EDA responses during the cold pressor stressor compared to women in the NTr group. Secondary analysis of EDA as a function of the grouping variable Rt demonstrated a significant interaction effect by condition (F (1, 43) = 7.11, *p* = .011), with women in the NRt group demonstrating significant differences in EDA response between pre and post stress condition. There was also a significant interaction for Ht x Condition (F (1, 43) = 6.50, *p* = .014), indicating that women in the Ht group showed reliably heightened phasic responses post stress compared to prestress.

3.3: Behavioral Response Analyses

To test the behavioral hypothesis regarding performance on the verbal fluency test (COWAT), a one-way between subjects ANOVA was completed comparing overall scores between the groups. The Levene test indicated a violation of homogeneity and the results were interpreted from the Welch's ANOVA. This analysis approached significance (F (1, 46) = 3.25, *p* = .078) with women in the NTr group scoring higher than women in the Tr group. Similarly, analyses of the behavioral results for figural fluency were completed for outcome scores from the figural fluency test (RFFT) and RFFT perseverative error scores using two one-way between subjects ANOVAs. No significant differences were recorded for performance on the RFFT or in the perseverative error scores. Secondary analyses were completed for each behavioral variable looking at group differences for Rt and Ht. Results from the secondary ANOVAs indicated no statistically significant results between groups for any of the behavior outcome variables.

4. Discussion

4.1: Hypothesis Review and Key Findings

The current experiment examined differences among women who have experienced rape trauma in their regulatory control over traditional physiological variables, including heart rate, electrodermal activity, and systolic blood pressure. Regulatory control was also assessed for lateralized neuropsychological indices of frontal lobe capacity regarding verbal fluency stress (left frontal), figural fluency stress (right frontal), and pain stress (right frontal). The experiment further examined the role of physical restraint in the production of diminished frontal lobe capacity for regulatory control over the autonomic nervous system, as well as the impact of a history of sexual assault extending beyond one year.

Primary results showed support for a number of the hypotheses presented with implications for understanding sexual assault as a specific trauma type and the impact it may have on functional neural systems. Overall, the findings provide evidence for diminished frontal lobe regulatory control over the autonomic nervous system as demonstrated by differences in both sympathetic and parasympathetic response to lateralized frontal lobe stressors. Deficits in the frontal regulation of the sympathetic response to right frontal stressors (figural fluency stress and pain stress) were particularly acute. As hypothesized, women in the trauma group demonstrated heightened cardiovascular responses when presented with the right frontal stressor. These findings implicate that women who have experienced rape may respond differently to external stressors compared to women who have not experienced this trauma type. Specifically, the findings support the hypothesis that women who have experienced rape may show increased sympathetic tone when faced with various external stressors. The implications for these findings are profound.

The current experimental design was based upon research looking at high hostile individuals and decreased right frontal regulatory control in response to similar stressors (see Cox & Harrison, 2008; Demaree, Harrison, & Rhodes, 2000; Holland, et. al, 2014). Extension of the findings in these prior studies described how people who have diminished regulatory control over right hemispheric processes, including sympathetic tone, may experience the world differently in the visual, auditory, and somatosensory processing of emotional events. If women who have experienced rape have a lower capacity for stress tolerance, particularly for right frontal stressors, then these women are theoretically more likely to experience increased cardiovascular response, intense emotional reactivity including fear and anger, and various other behavioral outcomes preferentially regulated by the right hemisphere. Similar to the way high hostile and cynical people experience the world, shifts in neural functioning within women who have been raped may cause them to see and experience the world differently. This alteration of perception may potentiate a negative emotional perceptual bias, resulting in coercive attempts at external control, which may include initiation of potentially deleterious responses and over reactivity of the sympathetic branch of the ANS.

Evidence from the collected self-report data on depression and anxiety further support this notion that rape as a trauma type may be particularly powerful at shifting the general experience of the individual. If the previously describe hypothesis for emotional and physiological changes in rape victims is accurate, then symptoms foundational to depression and anxiety may be more likely to present due to the decreased regulatory ability of the respective frontal lobes with emphasis at the right frontal regions. Similar associations can be made with the oft-reported symptoms of PTSD. Given the evidence presented, it is possible that many psychological symptoms demonstrated in women who have experienced rape are more likely due to the described neural changes, which have been shown to be foundational for the “mental” or “psychological” constructs of science.

4.2: Specific Findings

It was predicted that measures of hostility, in contrast with social desirability, would be affected by the grouping variable. Results indicated no significant difference between women who experienced rape versus those who did not, using traditional questionnaires purported to be sensitive to these constructs. While these findings were contrary to what was initially proposed, research on hostile presentations in women seems to support that contemporary measures for assessing cynical hostility may be inadequate with improved validity for assessing men. The current study included the MCDS in an attempt to capture constructs of behavior presentation that may be more indicative of hostility in women as defensive denial. Emerson & Harrison, (1990) proposed that a subset of highly reactive women exists, characterized by low levels of cynical hostility with high levels of denial. While the current experiment did not attempt to isolate anger as a construct for group identification, it is feasible that, had anger been assessed as opposed to hostility, women in the Tr may have matched with Emerson’s identified highly reactive subgroup of women. Comparative results on the MCDS were also not reliable. However, higher scores on both the MCDS and the CMHS were from women in the Tr group.

Mean comparisons of the anxiety and depression scores were partially supportive of the proposed hypothesis that women in the Tr group would show higher reported levels of anxiety and depression. Despite not reaching significance, women in the Tr group generally reported higher levels of anxiety than women in the NTr. It is estimated that a larger sample size may meet the significance threshold of $F < .05$. While differences on the self-report measure of depression were not reliable, the highest reported individual BDI scores were from women in the Tr group with the maximum being 41 (severely depressed). Interestingly, women who reported experiencing restraint during sexual assault had significantly heightened scores for both anxiety and depression. Similarly, women who reported a history of sexual assault greater than one year reported significantly higher scores on the anxiety measure, with depression scores also approaching significance. These results appear to support previous research indicating that rape is correlated with increased symptoms of anxiety and depression (Kilpatrick, Resick, & Veronen, 1981; Santiago, McCall-Perez, Gorcey, & Beigel, 1985).

The results of the mixed design ANOVAs for each of the biophysiological dependent variables (heart rate, electrodermal activity, and systolic blood pressure) provide important interaction effects that support the hypothesis that women in the Tr group showed significantly divergent physiological responses when compared with women in the NTr group. These differences were seen at the prestress versus post stress level within Condition and at all three levels of the Stressor variable. The interaction effects for measures of heart rate and blood pressure demonstrated that women in the Tr group had heightened sympathetic tone (heart rate, systolic blood pressure) when confronted with right frontal stressors. These heightened responses significantly increased as subjects within the Tr group attempted to shift from the pre to the post stress condition. While not tested in the current study, attention shifting has been shown to be a frontal stressor (Pribram & McGuinness, 1975) and may have further taxed frontal regulatory control with the subjects. Similarly, at the Stressor level, women in the Tr group demonstrated heightened levels of physiological reactivity to the various stressors. This reactivity further supports the proposed hypotheses as it demonstrates that women in the Tr group have difficulty regulating their sympathetic tone when faced with stress.

Post hoc analyses for the physiological dependent measures further elucidated differences within specific variables. For HR by Condition, women in the Tr group showed significant differences in sympathetic regulation of heart rate when faced with a stressor compared to baseline. Despite similar trajectories, a significant three-way interaction effect was observed between Groups x Stressor x Condition. These results demonstrate that while women in the Tr group respond in a similar fashion at each stressor level as the women in the NTr group, the responses of women in the Tr group to each stressor, including their heart rate response from pre to post stress condition, were significantly different. Interestingly, these differences became much more apparent when the grouping variable of physical restraint was added.

Women in the Rt group showed significantly higher HR responses to both the RFFT and the CP, as hypothesized. Similar results were seen for women in the Ht group. However, HR change as a response to the COWAT was variable across groups, with women in the Tr group demonstrating lower HR readings, women in the restraint group showing similar HR readings to their counterparts, and women in the History group showing higher HR readings. Follow-up analysis adjusting for a history of sexual assault in the control group resulted in an improved p value for comparisons between the Tr group and NTr, providing evidence that a history of sexual assault must also be considered as a potential moderating factor. Of particular interest, when history is controlled, a change in HR trajectory is observed with women in the Tr group showing significantly lower HR for the COWAT stressor and significant changes within each stressor variable only occurring for women in the Tr group. Exploring the impact of specific stressor types, for all three grouping variables, the CP stressor demonstrated the highest impact on HR response.

EDA phasic results were more variable than those seen for HR, which may reflect inherent event-related challenges associated with EDA acquisition. While none of the interactions for Stressor x Tr group were significant, including analyses controlling for history, women in the Tr group showed significantly higher EDA response to the CP stressor. Despite this lack of primary group differences, the grouping variables of Restraint and History both showed significant interactions by Condition with participants in both groups demonstrating consistently higher numbers of phasic responses within pre and post stress condition indicating a generally heightened sympathetic arousal state.

Systolic blood pressure (SBP) results tended to mirror those seen in HR, which would be expected. Women in the Tr group showed significantly higher SBP, both in regulatory control between pre and post stress condition and within each stressor. Secondary analyses supported previous HR findings with women in the Restraint group showing a significant interaction for Restraint x Stressor, with women in the Restraint group showing an overall higher SBP and women in the History group demonstrating decreased regulatory control between baseline and stressor.

Drawing from capacity theory, the observed physiological results provide evidence for decreased frontal regulatory control over sympathetic activation in women who have experienced rape trauma. Balance theory dictates that decreased left frontal control would be associated with increased parasympathetic tone via posterior release and associated neural processes implicated in parasympathetic activation, such as mobilization of acetylcholine in cholinergic postganglionic synapses (Hilz et. al, 2001; Iversen, Iversen, & Saper, 2000; Oppenheimer, Gelb, Girvin, & Hachinski, 1992). The homologue for right frontal deactivation has been observed in the resultant increase in sympathetic tone due to the right hemispheres generally preferential control of the sympathetic response (Foster et. al, 2008; Heilman et. al, 1978; Meerwijk, Ford, & Weiss, 2013; Wittling, 1997). For women in the Trauma group, stressors to both the left frontal (COWAT) and the right frontal (RFFT and CP) region resulted in diminished regulatory control over posterior neural circuits. With left frontal stress, release of posterior parasympathetic control was observed in decreased heart rate and blood pressure. Contralateral stress resulted in decreased regulation of posterior sympathetic response and increased heart rate and blood pressure. These differences were particularly acute when restraint was added as a moderating variable. Despite discrepancy between the physiological variables, observations within the trauma group showed overall increased variability for each stressor compared to the control group.

Shifting to the analyses of behavioral responses on the COWAT and RFFT, while not significant, women in the NTr group tended to perform better on the COWAT. No significant differences were observed between groups on the RFFT or RFFT perseverative errors, despite previously hypothesized differences on this instrument. Analysis of grouping variables, based upon Restraint and History, showed similar results.

At the stressor level, the most dramatic responses were to the cold pressor. Given the pain sensation associated with this stressor, it would follow that people may experience heightened physiological responses to this task. Across groups, women in the Tr group, particularly when Restraint was included, showed heightened physiological response to this stressor. As previously discussed, if rape trauma causes direct insults to regulatory neural systems based upon both emotional and somatosensory input, the pain stimulus should be substantially adequate to overwhelm these injured neural systems. Results from the current study support this hypothesis and show that women who have been subjected to sexual assault may experience painful sensory events with increased sensitivity and distress as compared to women who have not experienced sexual assault. Similarly, based upon valence theory and the evidence that the right hemisphere processes primarily intense emotional experience (Agustin-Pavon et. al, 2012; Heilman & Bowers, 1990) women in the Tr group may be acutely more sensitive to emotional stimulation given their proposed depletion of right frontal resources compared to women in the control group.

The implications for the findings from the current study extend to support the supposition that gender may play far less of a role in the formation of PTSD than previously surmised. If women who have a history of experiencing sexual assault are already at risk for diminished frontal regulation of systems implicated in PTSD, they will show higher rates of PTSD symptoms post trauma, regardless of the trauma type. If rape, as a specific trauma type, results in diminished frontal regulatory control, then many behavioral responses observed in people with similar neural deficits can be extended to this population. Such extensions may include behavior like approach and withdrawal (Foster et. al, 2008; Harmon-Jones, 2003), optimistic anticipation of future events versus negative reflection on past events (Harrison, 2015; Pujol et. al, 2002), and dominance versus submission (Demaree, Everhart, Youngstrom, & Harrison, 2005).

Some may argue that physiological differences observed between the Tr group and History group undermine some of the proposals made; however, an understanding of neural changes post trauma can serve to provide clarity for some of the observed differences. Capacity theory would argue that repeated insults would result in more severe and prolonged deficits in the impacted neural systems, with a relatively brief insult allowing for improved healing over time. Given that specific details of historical assault were not obtained from participants, there is no way to know if the events reported were short or if they happened over a continuous period of time. Despite this lack of specificity, when a reported history of sexual assault was accounted for in the non-trauma group, there was an overall increase in the sympathetic response of the Tr group. These findings imply that women who reported a history of assault greater than one year may have continuous neural deficits associated with the identified history, compared to women who reported never experiencing assault. Disturbingly, 57% of our sample reported a history of sexual assault.

While explored as a secondary analysis variable, the impact of restraint on the various dependent measures cannot be ignored. Within animal models, physical restraint and immobilization is a reliable and commonly used procedure to induce behavioral, physiological, and chemical stress reactions (Campos, Fogaca, Aguiar, & Guimaraes, 2013). Despite only having a sample size of 5 women in the restraint group, the significant observed differences in their output demonstrate that restraint may be a primary contributor to the subjective severity in the experience of a given stressor. For example, women in the Restraint group showed significantly heightened cardiovascular responses to the cold pressor stressor than women in either the Tr group or the History group, implicating further frontal regulatory deficits and the potential for the described changes. Differences were maintained when women in the restraint group were compared to women who reported rape without restraint. Given the powerful moderating role that this variable played in the current study, future efforts at discerning the overall impact of restraint should be made.

4.3: Limitations

Limitations of the current study include challenges associated with using psychological constructs, such as the CMHS, that have been traditionally used with a male population on women. The need for better research protocol with women is currently being explored within the larger field. However, some of the variation observed in the current experiment may be due to gender norming issues.

Another limitation was the use of young women from a convenient college aged sample. Past efforts have demonstrated young women are highly resilient to neurophysiological stressors and their response may not be indicative of brain function in an older population. Relatedly, given the need to recruit a specific population of women who had experienced rape, women with a PTSD diagnosis from rape may have shown greater significance in outcome measures.

Other limitations include generalized sex differences observed within neural systems. While lateralization has been demonstrated in women, many accepted hemispheric specializations, such as verbal processing, may be more or less distinct in women compared to men. Continued efforts need to be made to understand women’s unique neurological and physiological responses to stressors.

Only women were included in the present study, and while foundational to the experimental design, this gender bias is a limitation. It is recognized that men also experience rape and sexual assault. Analysis of men who were victims of rape would have provided improved reliability for the current study; however it was hypothesized that recruiting college aged men who would endorse a history of rape would be extremely challenging.

Finally, the determination of neural deficits from physiological response was another limitation. Despite years of psychophysiological research supporting the variables of heart rate, electrodermal activity, and systolic blood pressure as viable markers for neural activation, without follow-up studies exploring direct neural activation, the current findings must be viewed as preliminary. Although the findings appear to support the impact of rape on neural systems as presented through balance and capacity theories, the current experiment is limited by the outcome variables used.

4.4: Future Directions

The current experiment provides a good preliminary exploration of the impact rape may have on neural systems as a unique trauma type. Future research efforts should build upon the findings by continuing to assess neural processes, following a cerebral systems approach. Starting with arousal and moving through all five sensory modalities, future research can begin to clarify the impact rape has on specific neural functions. A systemic approach to understanding rape based upon neuropsychological theory can allow for increased understanding of the impact of rape and improved intervention strategies. Furthermore, associations between rape and PTSD cannot be ignored. By developing a body of evidence that defines the neural impact of rape, relational variables between PTSD symptom outcomes and rape can be more fully defined.

Following improved determination of the impact rape has on neural systems, future efforts should work to explore the proposed subjective experiential changes that may accompany rape. With greater theoretical constructs for the impact rape has on both objective systems and subjective experience, future efforts can be made to create targeted assessment and intervention strategies. To this end, neuropsychological screening tools can be established to help improve predictive validity for the risk of developing a mental health concern, such as PTSD, post rape. Directed interventions can also be created based upon neural system impact to help improve behavior outcomes for rape victims. This research is particularly important as some evidence shows that prior rape victims are at an increased risk for secondary assault. While the current study does not explore this disturbing finding, the findings support the concept that women who have experienced rape may interpret potentially risky situations differently compared to women who have not experienced rape, placing them at increased risk, including perceptual alterations, which may affect identification of potential perpetrators.

A limitation in the current study, future research efforts exploring the impact of rape on neural systems should include men as a grouping variable. Hypothetically, men should score differently than women on self-report measures. Biophysiological responses to each stressor may also differ. Rape, as a trauma type, has been shown to be equally distressing to men as it is to women (Rentoul & Appleboom, 1997) and future research efforts on this trauma type should consider inclusion of an all male population.

Despite having a low sample size, the impact of reported restraint on the outcome variables was significant. Future efforts should look exclusively at this variable, given the abundance of animal model research demonstrating the effectiveness of using physical restraint in the production of PTSD correlates. The preliminary findings within the current study show that restraint may play an important role in the neural impact of rape, but limited associations can be made. Future efforts can work to isolate physical restraint as a construct within various trauma types to determine the direct impact this construct may have on the brain.

Foundational to the current study is the use of physiological measures often employed in biophysiological and nueropsychological research. A broad literature base has been established looking at neural sex differences, but the research exploring the tranlation of these differences into physiological responses has beem limited. To provide improved reliability and validity, future research should incorporate exploring how men and women may respond differently to a frontal stressor like pain or figural fluency. This understanding may help clarify some of the group differences seen in the current study.

One final consideration, although many efforts have been made to define the epidemiological elements of rape, the evidence that a majority of the women in the current study reported a history of sexual assault implies the continued efforts are needed. Despite being advertised as a study exploring rape and PTSD, researchers assumed that finding women for the Tr group would be overly challenging. This, however, was not the case. Many experts looking at rape theorize that the generally accepted statistics for the incidence of rape may be low and the numbers from the current study appear to support this. Research efforts must continue to explore rape so that an improved understanding and subsequent interventions can translate into decreased incidence of rape-related trauma.

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Appendix A

Tables

Table 1

Sample Sizes for Group Variables

Group Variable	N
Trauma (Tr)	20
No Trauma (NTr)	27
Restraint (Rt)	5
No Restraint (NRt)	42
SA History (Ht)	27
No SA History (NHt)	20

Table 2

Descriptive Variables for Self-Report Measures

Variable	Mean	Standard Deviation	Minimum	Maximum
BDI	12.40	11.82	0	41
BAI	15.72	13.16	1	46
CMHS	22.23	8.49	6	40
MCDS	14.32	5.41	3	28

Table 3

Descriptive Variables for Behavior Performance Measures

Variable	Mean	Standard Deviation	Minimum	Maximum
COWAT	40.06	10.06	19	63
RFFT	42.36	10.57	11	61
RFFT PE	3.38	4.04	0	16

Table 4

Descriptive Statistics for Self-Report Measures According to Group

Group	BDI		BAI		CMHS		MCDS	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Trauma (Tr)	15.55	14.59	19.85	15.82	23.35	9.25	15.30	4.81
No Trauma (NTr)	10.07	8.87	12.67	10.04	21.41	7.96	13.59	5.79
Restraint (Rt)	25.00	7.97	37.20	5.17	27.20	8.70	14.60	6.58
No Restraint (NRt)	10.90	11.36	13.17	11.35	21.64	8.37	14.29	5.34
SA History (Ht)	15.28	11.37	19.44	12.98	22.56	9.48	14.40	5.52
No SA History (NHt)	9.14	11.73	11.50	12.32	21.86	7.41	14.23	5.41

Table 5

Descriptive Statistics for Behavioral Output According to Group

Group	COWAT		RFFT		RFFT PE	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Trauma (Tr)	37.25	7.06	42.65	10.98	3.25	4.44
No Trauma (NTr)	42.15	11.49	42.15	10.46	3.48	3.81
Restraint (Rt)	37.00	6.04	39.9	8.76	3.6	5.86
No Restraint (NRt)	40.43	10.43	42.69	10.81	3.36	3.87
SA History (Ht)	42.64	10.38	40.76	12.19	3.00	3.43
No SA History (NHt)	37.14	9.04	44.18	8.27	3.82	4.69

Table 6

Between-Subjects Effects for Self-Report Variables

Group Comparison	BDI		BAI		CMHS		MCDS	
	F Value	Pr > F	F Value	Pr > F	F Value	Pr > F	F Value	Pr > F
Tr x NTr	2.21	0.15	3.18	0.08	0.60	0.44	1.15	0.29
Rt x NRt	7.21	***0.01**	21.56	***<0.01**	1.95	0.17	0.01	0.90
Ht x NHt	3.32	0.07	4.49	***0.04**	0.08	0.78	0.01	0.91

** - Findings were statistically significant at the .05 level*

Table 7

Between-Subjects Effects for Behavioral Outcome Variables

Group Comparison	COWAT		RFFT		RFFT PE	
	F Value	Pr > F	F Value	Pr > F	F Value	Pr > F
Tr x NTr	3.25	0.08	0.02	0.88	0.04	0.85
Rt x NRt	0.51	0.48	0.38	0.54	0.02	0.90
Ht x NHt	3.71	0.06	1.23	0.27	0.47	0.49

Table 8

Within-Subjects Effects for Heart Rate (HR) Dependent Variable

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Condition	1	43	14.39	0.0005
Stressor	2	86	11.73	<.0001
SES	1	43	0.01	0.92
R-SES	1	43	0.63	0.4311
H-SES	1	43	0.55	0.4605
Condition*Stressor	2	74	5.7	0.005
Condition*SES	1	43	7.79	0.0078
Condition*R-SES	1	43	0.09	0.7599
Condition*H-SES	1	43	1.48	0.23
Stressor*SES	2	86	2.64	0.0774
Stressor*R-SES	2	86	6.42	0.0025
Stressor*H-SES	2	86	5.69	0.0048
Conditi*Stressor*SES	2	74	1.57	0.2141
Condit*Stresso*R-SES	2	74	0.41	0.6676
Condit*Stresso*H-SES	2	74	2.24	0.1137

Table 9

Significant Pairwise Comparisons for Interaction Effects of Heart Rate (HR) Dependent Variable

Differences of Least Squares Means								
Effect	Interaction1	Interaction2	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Condition*Stressor	C1xS1	C2xS3	-9.8853	1.5396	74	-6.42	<.0001	<.0001
Condition*Stressor	C1xS2	C2xS3	-7.8864	1.5396	74	-5.12	<.0001	<.0001
Condition*Stressor	C2xS3	C2xS3	-7.4089	1.5396	74	-4.81	<.0001	0.0001
Condition*Stressor	C2xS1	C2XS3	-7.3972	1.5396	74	-4.8	<.0001	0.0001
Condition*Stressor	C2xS2	C2xS3	-7.6673	1.5396	74	-4.98	<.0001	<.0001
Condition*SES	C1xTr1	C2xTr1	-5.8525	0.865	43	-6.77	<.0001	<.000
Stressor*SES	S1xTr1	S3xTr1	-7.3372	1.0594	86	-6.93	<.0001	<.0001
Stressor*SES	S2xTr1	S3xTr1	-4.668	1.0594	86	-4.41	<.0001	0.0004
Stressor*R-SES	S1xRt1	S3xRt1	-8.8306	2.0981	86	-4.21	<.0001	0.0009
Stressor*R-SES	S2xRt1	S3xRt1	-6.2338	2.0981	86	-2.97	0.0038	0.0431
Stressor*R-SES	S2xRt2	S3xRt2	-1.911	0.5841	86	-3.27	0.0015	0.0186
Stressor*H-SES	S1xHt2	S3xHt2	-6.8049	1.3167	86	-5.17	<.0001	<.0001
Stressor*H-SES	S2xHt2	S3xHt2	-5.1825	1.3167	86	-3.94	0.0002	0.0023

Table 10

Within-Subjects Effects for Systolic Blood Pressure (SBP) Dependent Variable

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Condition	1	43	16.73	0.0002
Stressor	2	86	3.62	0.0309
SES	1	43	0.45	0.5075
R-SES	1	43	0.01	0.9331
H-SES	1	43	0.45	0.5039
Condition*Stressor	2	74	3	0.0557
Condition*SES	1	43	10.06	0.0028
Condition*R-SES	1	43	0.01	0.9093
Condition*H-SES	1	43	4.79	0.0342
Stressor*SES	2	86	10.89	<.0001
Stressor*R-SES	2	86	5.45	0.0059
Stressor*H-SES	2	86	0.01	0.9885
Conditi*Stressor*SES	2	74	2.22	0.1155
Condit*Stresso*R-SES	2	74	1.19	0.3112
Condit*Stresso*H-SES	2	74	2.11	0.128

Table 11

Significant Pairwise Comparisons for Interaction Effects of Systolic Blood Pressure (SBP) Dependent Variable

Differences of Least Squares Means								
Effect	Interaction1	Interaction2	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Condition*SES	C1xTr1	C2xTr1	-7.4426	0.9973	43	-7.46	<.0001	<.0001
Condition*H-SES	C1xHt1	C2xHt1	-3.044	1.0558	43	-2.88	0.0061	0.03
Condition*H-SES	C1xHt2	C2xHt2	-5.3391	1.2396	43	-4.31	<.0001	0.0005
Stressor*SES	S1xTr1	S3xTr1	-4.0559	1.2215	86	-3.32	0.0013	0.0161
Stressor*SES	S1xTr2	S1XTr2	7.2143	2.1933	86	3.29	0.0015	0.0177
Stressor*SES	S2xTr1	S3xTr1	-6.0038	1.2215	86	-4.92	<.0001	<.0001
Stressor*R-SES	S1xRt2	S3xRt2	-2.5606	0.6734	86	-3.8	0.0003	0.0035
Stressor*R-SES	S2xRt2	S3xRt2	-4.0624	0.6734	86	-6.03	<.0001	<.0001

Table 12

Within-Subjects Effects for Electrodermal Activity (EDA) Dependent Variable

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Condition	1	43	3.81	0.0575
Stressor	2	86	0.98	0.38
SES	1	43	5.71	0.0213
R-SES	1	43	0.08	0.7821
H-SES	1	43	0	0.9691
Condition*Stressor	2	74	1.69	0.1924
Condition*SES	1	43	0.64	0.4277
Condition*R-SES	1	43	7.11	0.0108
Condition*H-SES	1	43	6.5	0.0144
Stressor*SES	2	86	0.47	0.6286
Stressor*R-SES	2	86	0.44	0.6461
Stressor*H-SES	2	86	0.43	0.6489
Conditi*Stressor*SES	2	74	0.61	0.5466
Condit*Stresso*R-SES	2	74	0.02	0.9789
Condit*Stresso*H-SES	2	74	0.12	0.8897

Table 13

Significant Pairwise Comparisons for Interaction Effects of Electrodermal Activity (EDA) Dependent Variable

Differences of Least Squares Means								
Effect	Interaction1	Interaction2	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P
Condition*R-SES	C1xRt2	C2xRt2	-1.1225	0.1304	43	-8.61	<.0001	<.0001
Condition*H-SES	C1xHt1	C2xHt1	-0.7914	0.2503	43	-3.16	0.0029	0.0147

Figures

Figure 1

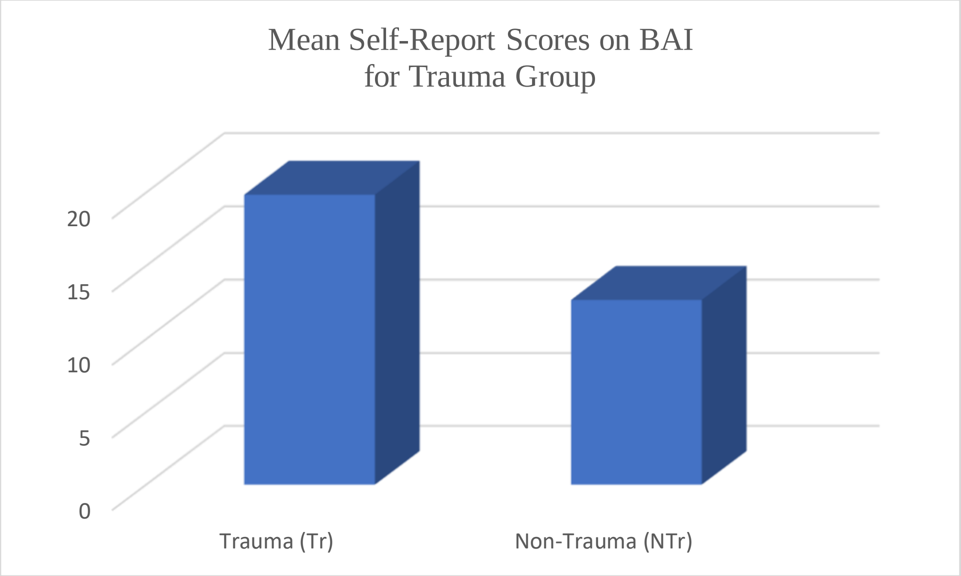


Figure 2

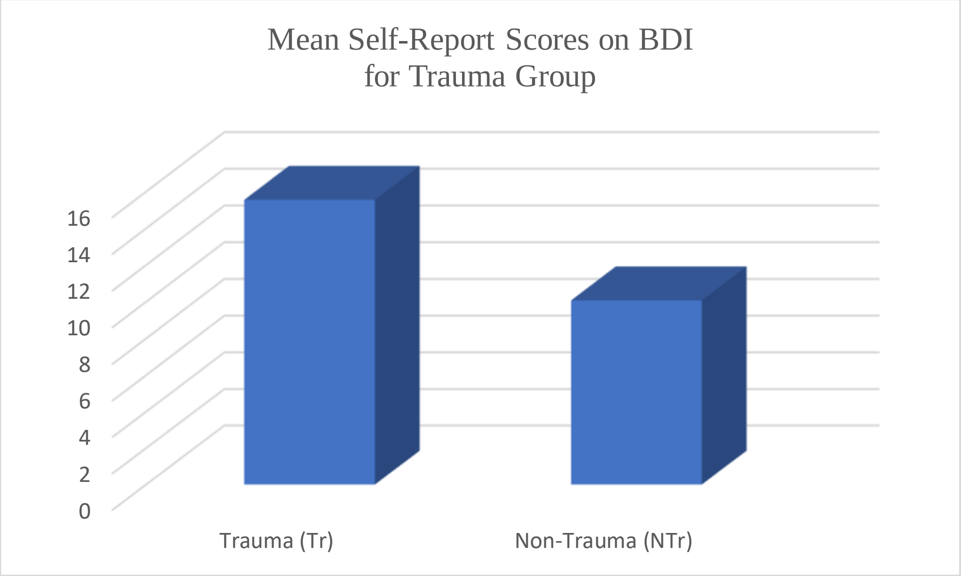
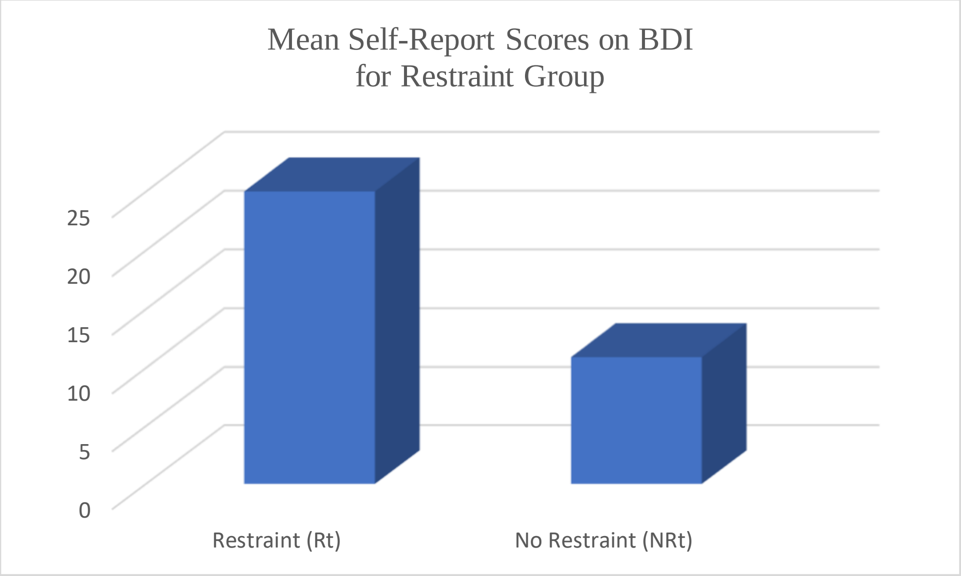


Figure 3



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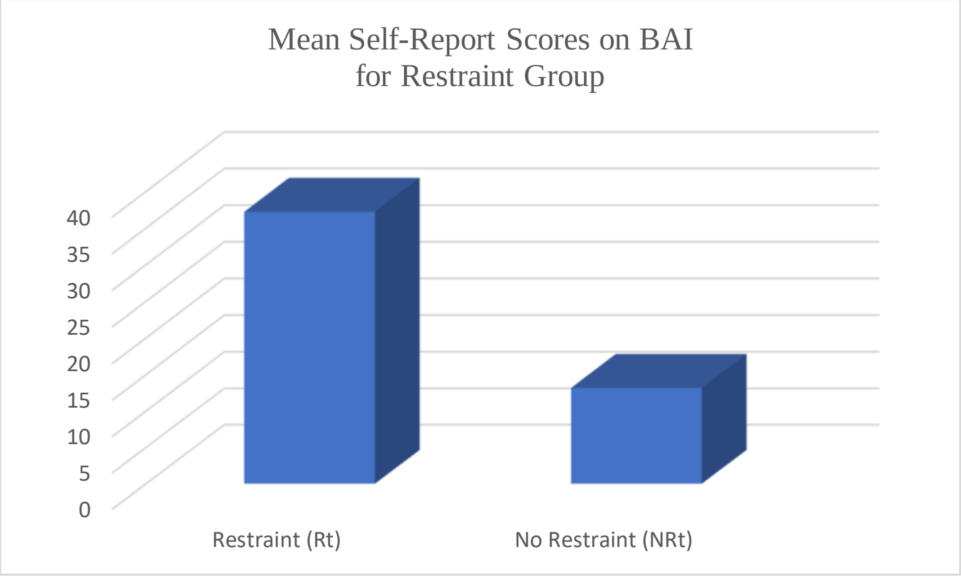

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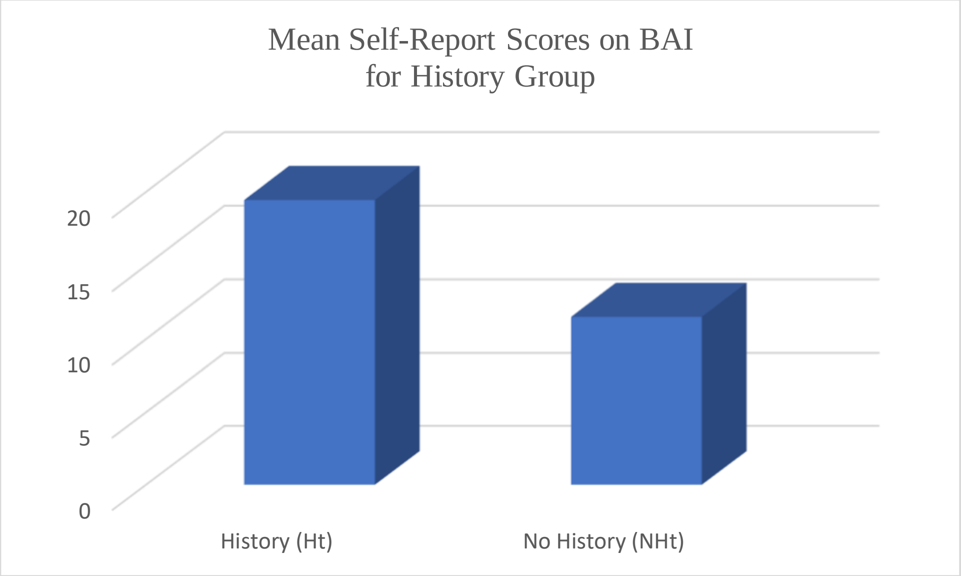

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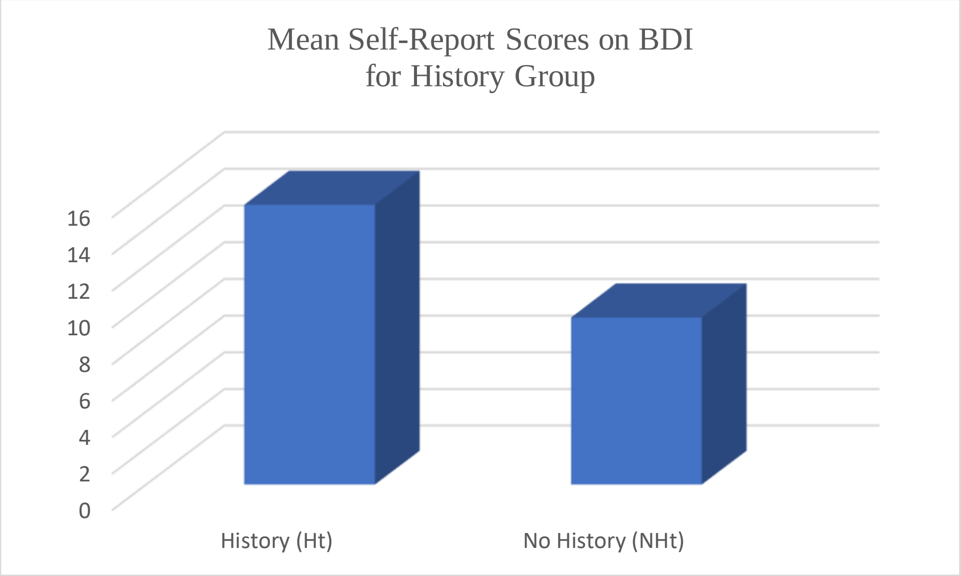

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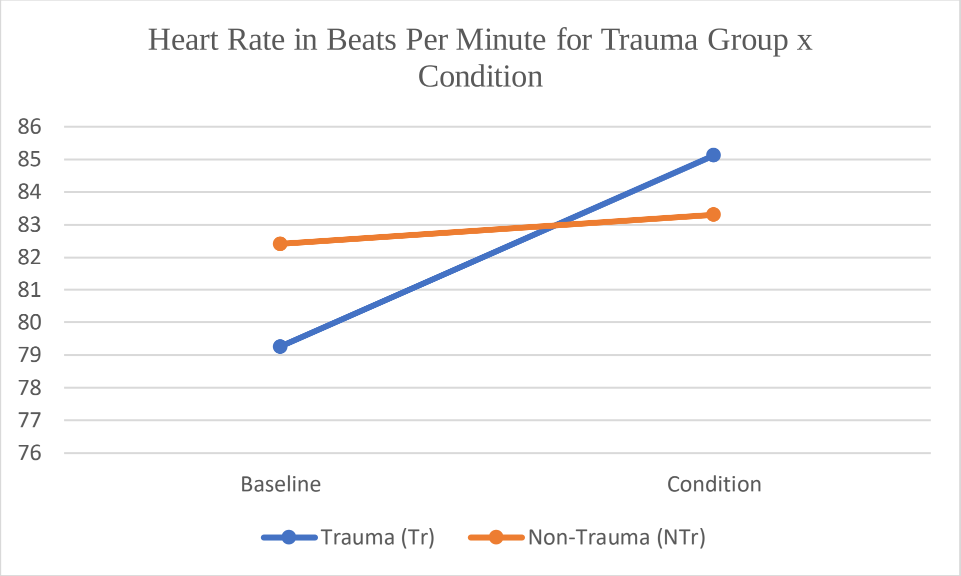

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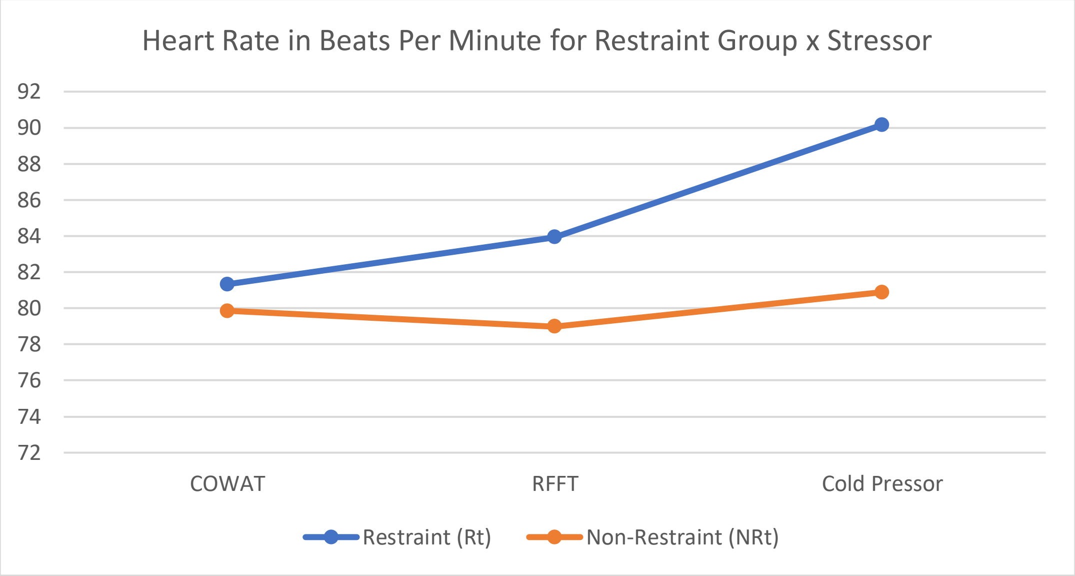


Figure 9

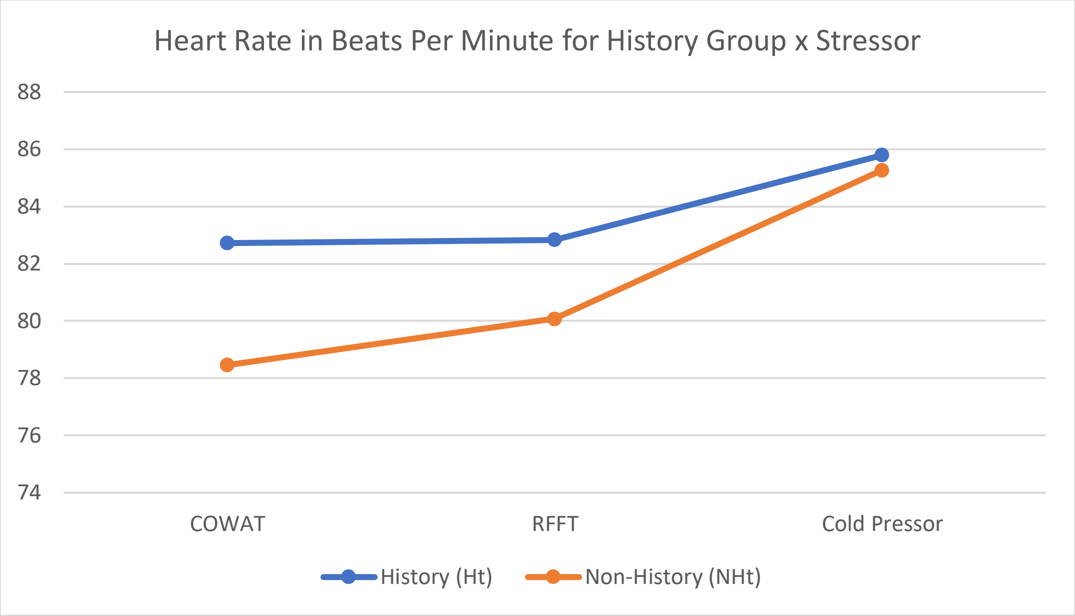


Figure 10

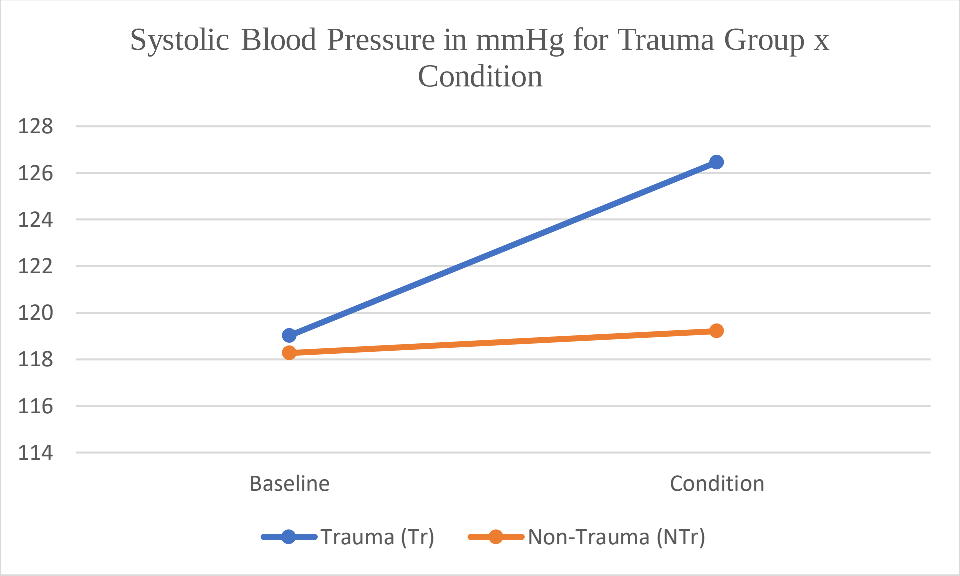
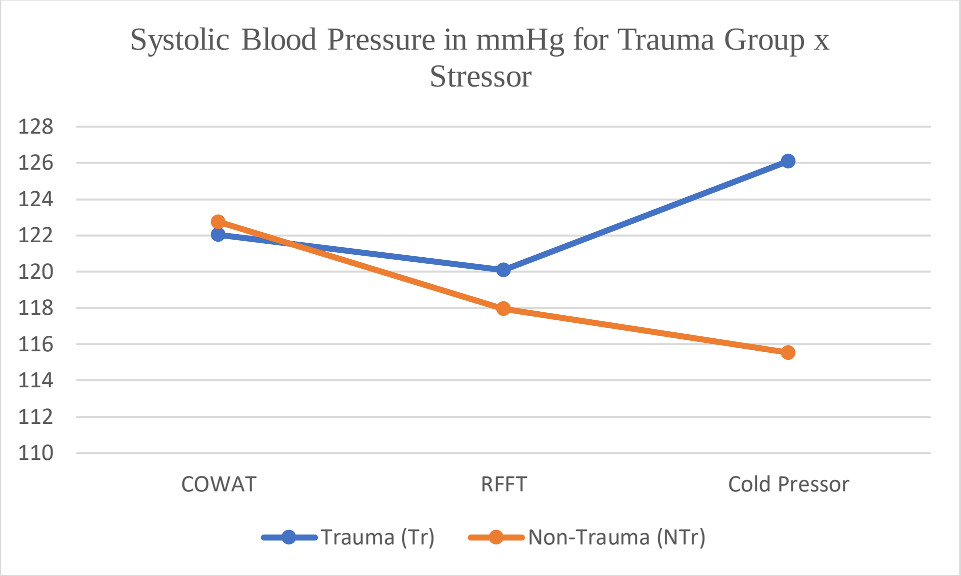


Figure 11



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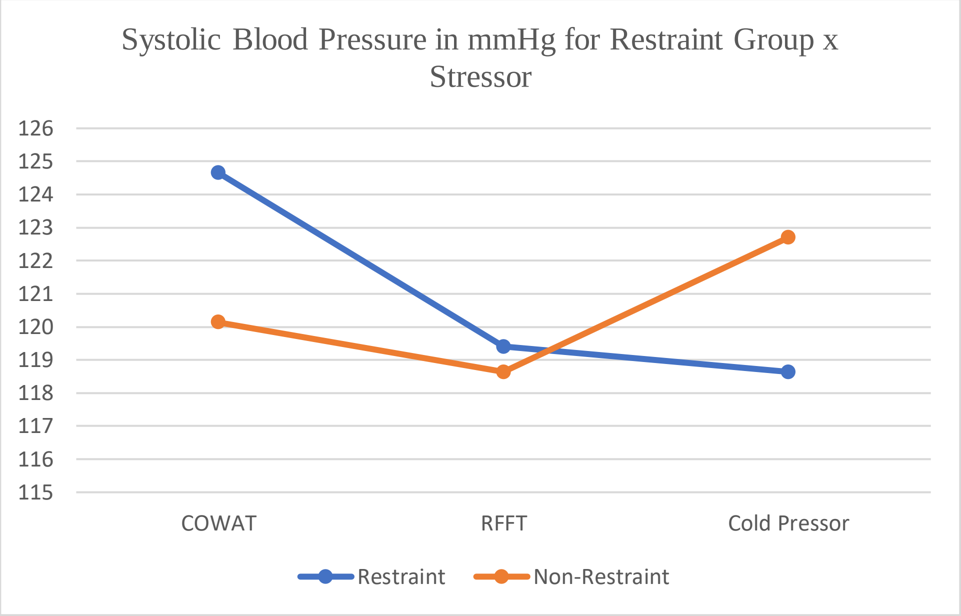

Figure 13

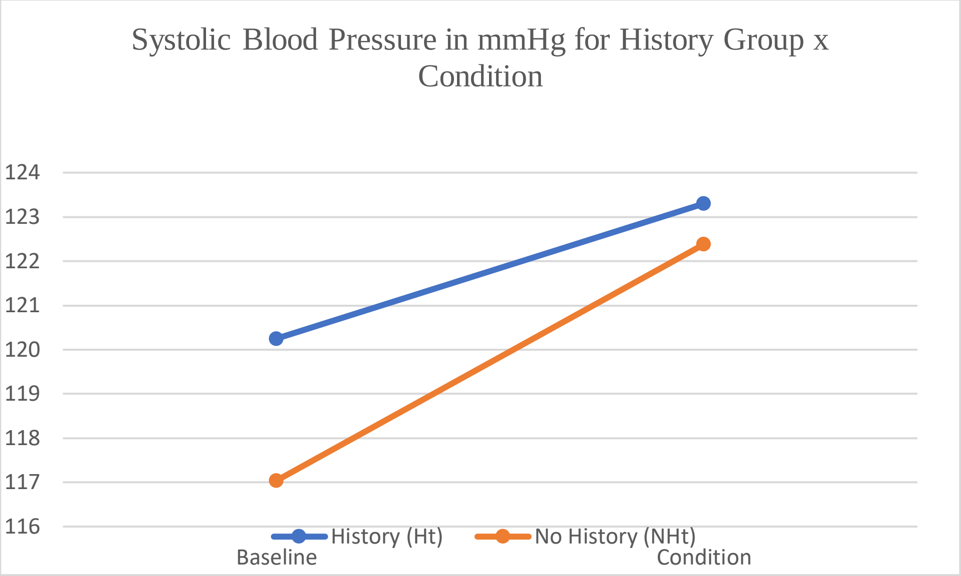

Figure 14