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Trauma and psychophysiological reactivity: menstrual phase, posttraumatic stress disorder, and performance on a loud tones task

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TRAUMA AND PSYCHOPHYSIOLOGIC REACTIVITY: MENSTRUAL PHASE, POSTTRAUMATIC STRESS DISORDER, AND PERFORMANCE ON A LOUD TONES TASK

by

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TRÁUMA AND PSYCHOPHYSIOLOGIC REACTIVITY: MENSTRUAL PHASE, POSTTRAUMATIC STRESS DISORDER, AND PERFORMANCE ON A LOUD TONES TASK

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ABSTRACT

The current study examines the effects of Posttraumatic Stress Disorder (PTSD) and menstrual cycle phase on psychophysiologic reactivity to a loud tones task in a population of female trauma survivors. Estradiol and progesterone fluctuate throughout the menstrual cycle; prior research has shown the variety of effects these hormones have on the Hypothalamic-Pituitary Adrenal (HPA) axis, glucocorticoids, stress and anxiety homeostasis, and conditionability. We hypothesized greater reactivity for participants with PTSD, and that menstrual cycle would moderate the effects of PTSD and performance on the loud tones task. Results indicated heart rate was higher in participants in the mid-luteal phase than early follicular phase. Several results were surprising, including that participants with PTSD demonstrated less startle reactivity and faster habituation (as measured using the left orbicularis electromyogram (O-EMG) measure) than participants in the trauma control group for. Considerations are made for demographics, sample size, and the number of potential underlying mechanisms for PTSD.
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LIST OF ABBREVIATIONS

ACTH.......................................................... Adenocorticotropic Hormone
ALLO.......................................................... Allopregnanolone and its derivatives
ASR.................................................................. Auditory Startle Reflex
BLA.............................................................. Basolateral Nucleus of the Amygdala
BNST............................................................ Bed Nucleus of the Stria Terminalis
CeA.............................................................. Central Nucleus of the Amygdala
CR............................................................... Conditioned Response
CRH.............................................................. Corticotropin Releasing Hormone
CS............................................................... Conditioned Stimulus
DSM............................................................. Diagnostic and Statistical Manual
eFP.............................................................. Early Follicular Phase
EMG............................................................. Electromyogram
FSH............................................................. Follicular Stimulating Hormone
GABA......................................................... Gamma-Aminobutyric Acid
HPA Axis..................................................... Hypothalamic-Pituitary-Adrenal Axis
HR............................................................. Heart Rate
HRR............................................................ Heart Rate Response
HSD............................................................. Hydroxysteroid Dehydrogenase
LC.............................................................. Locus Coeruleus
LH.............................................................. Luteinizing Hormone
MDD.......................................................... Major Depressive Disorder
mLP.................................................................Mid-Luteal Phase
mPFC.................................................................Medial Prefrontal Cortex
NE.................................................................Norepinephrine
NPY.................................................................Neuropeptide Y
O-EMG.............................................................Orbicularis Electromyogram
O-EMGR.........................................................Orbicularis Electromyogram Response
PFC.................................................................Prefrontal Cortex
PTSD.............................................................Post-Traumatic Stress Disorder
PVN...............................................................Paraventricular Nucleus
SC.................................................................Skin Conductance
SCR...............................................................Skin Conductance Response
UCS...............................................................Unconditioned Stimulus
INTRODUCTION

POSTTRAUMATIC STRESS DISORDER

Since the mid-1800s, Posttraumatic Stress Disorder (PTSD) has borne a number of names. Prior to this time, soldiers sometimes experienced “nostalgia” – missing home, sleep problems, and anxiety, among other symptoms. This formed the basis of a psychological injury model for understanding these symptoms in Civil War soldiers. Models based on the physical components of post-trauma reactions (e.g., rapid pulse, anxiety, and trouble breathing) gave rise to other terms, such as soldier’s heart, railroad spine, and shell shock, which was specific to World War One. A variety of treatments were attempted, including hypnosis and electrotherapy. During World War Two, the shell shock diagnosis became known as Combat Stress Syndrome, or battle fatigue, due to long campaigns. While some doubted the affliction’s existence, the U.S. military worked to treat those suffering from battle fatigue promptly in an effort to help soldiers return to the front lines (“History of PTSD”, 2015).

In 1952, the first Diagnostic and Statistical Manual-I (DSM-I) was developed for use in assessment and diagnosis of mental health problems. In the DSM-I, the condition’s name changed yet again to “gross stress reaction,” and now included civilians among those who could be affected. With the DSM-II, the diagnosis was eliminated and replaced with “adjustment reaction to adult life,” a highly limited substitute that didn’t capture the qualities of PTSD like its predecessors. The term “Posttraumatic Stress Disorder” was first used after the Vietnam War. This term described soldiers returning from combat,
Holocaust survivors, sexual assault victims, and others who exhibited hyperarousal, nightmares, flashbacks, and re-experiencing in an intrusive and distressing manner (“History of PTSD in Veterans”, 2015).

PTSD was first found in the third edition of the DSM in 1980 (DSM-III). Depression and anxiety were listed as common comorbid diagnoses, along with other features such as compulsive behaviors, pseudo-organic symptoms, and survivor’s guilt. Since then, PTSD has undergone revisions throughout later editions of the DSM, the DSM-IV, DSM-IV-TR, and DSM-5. Once categorized as an anxiety disorder, in the DSM-5 PTSD is now listed in a separate category, Trauma- and Stressor-Related Disorders (“History of PTSD in Veterans”, 2015). According to the DSM-5, there are four primary types of symptoms: reliving the event (re-experiencing), avoiding situations that remind one of the event, negative changes in beliefs and feelings, and hyperarousal (“Symptoms of PTSD”, 2015).

This is by no means a recent phenomenon. Abdul-Hamid and Hughes (2014) notes Herodotus’ account of Epizelus, an Athenian spear carrier at the battle of Marathon, which is considered to be the first documented case of PTSD in historical literature, but provides evidence of much earlier accounts primarily from Mesopotamia. The Mesopotamians valued the power of diagnosis: they often believed disease was the result of the gods’ displeasure with the patient via demons or spirits invading them. Though counterintuitive, this is closer to the modern concept of foreign bodies infecting patients than the Greek notion of bodily humors being imbalanced. Symptoms of hyperarousal, avoidance, flashbacks and re-experiencing, and cognitive changes were described in the
extensive military records of the Mesopotamians, for whom military service was required of the male population. The symptoms were attributed to “roving” or “roaming” ghosts that altered the mental state and caused a “wandering mind.”

PTSD is frequently associated with combat and war veterans, but civilians are afflicted as well. According to the Department of Veteran Affairs, recent data shows just how common PTSD is: 4% of men and 10% of women will develop PTSD in their lifetime (“History of PTSD in Veterans”, 2015). Breslau et al. (1998) studied a survey of 2182 residents of Detroit in 1996 and found that while women were half as likely as men to be exposed to assaultive violence and other injury or shock trauma types, women were found to be more than two times as likely to develop PTSD after exposure as men: 13.0% versus 6.2%, respectively. In terms of duration, 26% of individuals with PTSD diagnoses remitted by 6 months and 40% remitted by 12 months. When broken down by sex however, PTSD in women lasted four times as long as in men (48.1 months compared to 12.0 months, respectively). The authors concluded that sex is a significant risk factor for developing and maintaining PTSD.

**MENSTRUAL CYCLE**

Considering sex differences in PTSD, one significant difference between men and women comes to mind: the menstrual cycle. Beginning at puberty, women typically follow approximately a 28- to 32-day cycle until menopause occurs, starting between the ages of 45 and 55.

The hormonal component of the menstrual cycle can be broken down into the luteal and the follicular phases, named for the prevalence of follicular stimulating
hormone (FSH) and luteinizing hormone (LH). A surge of luteinizing hormone around day 12 of a standard 28 day cycle results in ovulation. The ovum is released from the ovary into the oviduct and travels toward the uterus. If it is not fertilized by a sperm, the ovum does not implant in the uterine wall and is expelled with the shedding uterine lining at menstruation. The corpus luteum is formed upon release of the ovum from the ovary and produces the hormones estrogen and progesterone. These hormones reach their highest levels together during the mid-luteal phase (mLP). Once the corpus luteum atrophies, estrogen and progesterone levels drop; progesterone helps maintain the uterine lining and, with this decrease, menstruation begins. During the early follicular phase (eFP), estrogen and progesterone levels are at their lowest points during the cycle (see Figure 1).

![Diagram of the menstrual cycle](image)

**Figure 1: The menstrual cycle.** Nillni, Toufexis, and Rohan, (2011).
Research on the interaction of PTSD and the menstrual cycle is still fairly limited. Literature shows women with PTSD experiencing increased levels of depression and phobic anxiety during the early follicular phase compared to the mid-luteal phase (Nillni, et al., 2015). This finding suggests low estrogen and progesterone levels may affect emotion and fear regulation. Glover et al. (2012) found hormonal status, specifically low estrogen, influences fear inhibition in both healthy and traumatized participants, which supports the idea of estrogen and progesterone having a role in anxiety regulation. In a study by Nillni et al. (2015) women with PTSD in the eFP demonstrated higher anxiety than during the mLP. Bryant et al. (2011) studied the association of the menstrual cycle and traumatic memories, concluding that women who experienced the initial trauma during the luteal phase were 3.68 times more likely to experience flashbacks. The study also found those who were in the luteal phase during the study were 4.89 times more likely to experience flashbacks than those in the follicular phase during the study. Trauma experienced during the luteal phase may be encoded in memory more strongly than during the follicular phase. Thus, there is emerging support for the possibility of PTSD being influenced by the menstrual cycle and associated hormone levels.

Possible mechanisms for this association involve several components: progesterone, allopregnanolone and its derivatives (collectively termed ALLO), and γ-aminobutyric acid (GABA). ALLO is a metabolite of progesterone by a two-step enzymatic pathway (see Figure 2). ALLO acts as a potent allosteric agonist of the GABA\textsubscript{A} receptor, which is found in the central nervous system, and GABA acts as the primary inhibitory neurotransmitter. Following ovulation, progesterone peaks in the mid-
luteal phase. In healthy individuals ALLO levels subsequently increase during the mLP, which then binds to GABA\(_A\) and promotes inhibition in the central nervous system. Once the corpus luteum degrades at the end of the luteal phase and menstruation begins, progesterone rapidly decreases. The subsequent abrupt drop in ALLO may produce an anxiogenic effect rather than its usual anxiolytic effect (Nillni, Toufexis, & Rohan, 2011). This is a window of vulnerability with regard to developing PTSD and other anxiety disorders.

Figure 2: *Progesterone synthesis and metabolism*. Schumacher, Hussain, Gago, Oudinet, Mattern, and Ghoumari (2012).

Another possible mechanism involves these same components in the context of glucocorticoids. Progesterone causes increased glucocorticoid release by acting as a weak
agonist of the glucocorticoid receptor (Lei et al., 2012; Attardi et al., 2008; Bryant et al., 2011). There is evidence that glucocorticoids play a role in memory encoding and that there is increased glucocorticoid release during the luteal phase as a result of increased progesterone levels. Trauma experienced then, particularly in the mLP, is more likely to be encoded for this reason. Bryant et al. (2011) suggest this is due to progesterone stimulating glucocorticoids during the traumatic event taking place during the luteal phase, making it more likely for these women to consolidate the traumatic memories. However, because ALLO stimulating GABA would typically be protective against flashbacks and anxiety, a problem in the conversion of progesterone to ALLO could lead to reduced GABAA functioning and lower inhibition in the central nervous system, allowing for greater physiologic reactivity in response to traumatic or startling stimuli during the luteal phase (Uzunova, Ceci, Kohler, Uzunov, & Wrynn, 2003; Rasmusson et al., 2006; Nillni, Toufexis, & Rohan, 2011).

**NEUROBIOLOGY AND MODELS OF ANXIETY**

There are several structures in the central nervous system involved in fear and anxiety regulation. The amygdala and the hippocampus are particularly important, as well as the bed nucleus of the stria terminalis (BNST), a structure running along the margin of the thalamus, and the central nucleus of the amygdala (CeA). Among other functions the BNST acts as a relay site for the hypothalamic-pituitary-adrenal axis (HPA axis) (Choi, Furay, Evanson, Ostrander, Ulrich-Lai, & Herman, 2007). It is also sexually dimorphic, twice as large in men as in women (Swaab, 2007). The CeA is the major output nucleus of the amygdala. It is largely responsible for the autonomic aspects of emotions by
connecting with the lateral hypothalamus and the brainstem (Kalin, Shelton, & Davidson, 2004; Keifer, Jr., Hurt, Ressler, & Marvar, 2015).

Makino et al. (1999) recorded corticotropin-releasing hormone (CRH) mRNA levels in the hypothalamus and the amygdala following psychological stress in rats. While there wasn’t a clear result of which structure was more sensitive, the study found increased levels of CRH mRNA in the CeA and the dorsolateral BNST. Lee and Davis (1997) also looked at the role of the BNST and CeA in anxiety regulation through CRH release after stress, this time using acoustic startle, by injecting CRH intracerebroventricularly. They found the BNST reacted most strongly to the intracerebroventricular CRH, suggesting the BNST is the primary location of receptors involved in the acoustic startle reflex (ASR).

**Stress Response.** The sympathetic nervous system is pivotal in launching a stress response. The term “fight or flight” exemplifies how the sympathetic nervous system responds to stress: heart rate increases, peripheral blood flow increases so muscles can be more oxygenated, sweat glands are activated, pupils dilate, and renin is secreted in the kidneys. Stressors stimulate the paraventricular nucleus (PVN) of the hypothalamus to secrete CRH (a peptide hormone and a neurotransmitter), which travels through the hypothalamo-hypophyseal portal system to the anterior pituitary gland. There CRH binds to receptors on corticotropes and stimulates the production of adrenocorticotropic hormone (ACTH) and β-endorphins. ACTH is secreted in the blood and acts on the adrenal glands, stimulating production of cortisol, glucocorticoids, and DHEA as well as mineralocorticoids. Cortisol subsequently stimulates gluconeogenesis and acts as a
diuretic. These and other actions collectively increase glucose, potassium, and sodium concentrations in the system. Cortisol contributes to fight or flight by mobilizing fatty acids, glucose, and amino acids so they are available to create a boost of energy. Cortisol also suppresses the immune system and increases blood pressure. Catecholamines like norepinephrine and epinephrine bind to receptors at a number of sites, leading to accelerated heart rate and other aforementioned components of the stress response.

The BNST also has a high concentration of CRH-containing cell bodies, projecting into several parts of the brainstem including the parabrachial nuclei. CRH perikarya at the CeA send terminals to the parabrachial nuclei and the BNST, both of which then send projections to the parvocellular region of the PVN. Thus CRH may influence neuroendocrine and autonomic functioning: a signal registering at the amygdala could stimulate CRH production at the PVN and subsequently the HPA axis through these neural connections (Arborelius, Owens, Plotsky, & Nemeroff, 1999).

Depression and anxiety disorders have been linked to malfunctioning in the HPA axis. Individuals with depression may have a hyperreactive HPA axis (Plotsky, Owens, & Nemeroff, 1995). The hypercortisolemia due to a hyperreactive HPA axis is considered a state quality of depression rather than a trait such that it is related to a particular phase of the illness rather than consistently present (Gillespie & Nemeroff, 2005); while counterintuitive when considering fight or flight, it may lead to compensatory effects like a blunted ACTH response to high levels of CRH or a downregulation of pituitary CRH receptors secondary to increased hypothalamic CRH. For example, fewer CRH receptors were found in the prefrontal cortex (PFC) of suicide victims, suggesting a compensatory
adaptation to chronically high CRH in this region (Arborelius et al., 1999). ALLO has been shown to have anxiolytic- and antidepressant-like effects. Uzunova et al. (2003) showed decreased ALLO levels in the cerebrospinal fluid of individuals with major depressive disorder, which has been shown to increase with successful antidepressant therapy and reversal of psychopathology. In this study, olfactory bulbectomized rats were used to model depression experimentally; following surgery the rats’ ALLO levels dropped drastically in the amygdala and frontal cortex. As ALLO is a strong positive endogenous allosteric modulator of the GABA_A receptor, this indicates reduced ALLO in depressive individuals may contribute to reduced GABA_A activation and GABAergic tone in the amygdala and frontal cortex (Uzunova, Ceci, Kohler, Uzunov, & Wrynn, 2003).

The anxiogenic effects of CRH have been hypothesized to be in part regulated by CRH acting on the noradrenergic systems of the locus coeruleus (LC) (Arborelius et al., 1999). At the LC, there are synaptic connections between CRH-containing terminals from the CeA and dendrites or noradrenergic neurons in the LC. CRH released here at the LC causes NE to be released, causing a stress-induced anxiety and aversion response. Increases in LC-NE activity are anxiogenic (Yajie, Hunt, & Sah, 2015). With repeated stress, tyrosine hydroxylase, the rate limiting enzyme in NE synthesis, is elevated; since this can be blocked by a certain CRH antagonist, it appears the process is at least partly dependent on CRH (Arborelius et al., 1999). Rajbhandari, Baldo, and Bakshi (2015) demonstrated that rodents exposed to repeated stress developed long-lasting sensitization
of basolateral nucleus of the amygdala (BLA) norepinephrine α1 receptors though a CRH-dependent mechanism, manifesting as heightened startle.

In individuals with PTSD, there is a difference in the way the HPA axis malfunctions: there are higher CRH concentrations in cerebrospinal fluid (CSF) and there is a blunted ACTH response to high CRH, but they show hypocortisolism, unlike in patients with other anxiety disorders (Arborelius et al., 1999). This suggests a difference in the HPA axis where cortisol is produced at the adrenal gland.

Figure 3: The hypothalamic-pituitary-adrenal axis. Hyman, (2009).

Glucocorticoids are released from the zona fasciculata of the adrenal cortex in response to ACTH. Glucocorticoids, including cortisol, stimulate gluconeogenesis and
play a role in memory consolidation. They interact with the hypothalamic-pituitary-gonadal axis at a number of levels – indirectly at the brain, directly at the gonads. The ways glucocorticoids influence functioning at these organs depend on the presence of glucocorticoid receptors. At basal HPA axis levels, glucocorticoids can inhibit GnRH and progesterone acts to protect GnRH (Calogero et al., 1999). Stress-induced HPA activity causes a rise in glucocorticoid release, which dampens the HPA axis through negative feedback (see Figure 3) and inhibits GnRH. Subsequently FSH and LH levels drop. However glucocorticoids have a synergistic effect on FHS-stimulated progesterone: glucocorticoids enhance progesterone production and inhibit progesterone metabolism by stimulating 3β-hydroxysteroid dehydrogenase (3β-HSD), which converts pregnenolone to progesterone, and inhibiting 20α-HSD, which metabolizes progesterone to cofactors and a progesterone-like derivative (Whirledge & Cidlowski, 2010). Thus, with more progesterone, more ALLO ought to be made, and ultimately more GABA as well due to increased allosteric modulation via ALLO at GABA_A receptors. A deficiency in ALLO due to a malfunctioning enzyme in the progesterone metabolism pathway is one potential mechanism underlying PTSD symptoms (Rasmusson et al., 2006).

**FEAR CONDITIONING**

Beyond the hormonal and physiologic aspects, behavior plays a significant role in PTSD. One theoretical model of PTSD is based on learning theory. According to learning theory models, specific stimuli, innocuous or otherwise, present during the event become associated with a traumatic event such that when those stimuli are encountered after the event the feelings associated with the trauma are reawakened. These associations can be
changed via extinction learning over time: with every new exposure to the stimuli in the absence of a trauma a new association in which the lack of threat is learned. However, some individuals have difficulty with extinction learning or retention of extinction learning. These individuals may be those who develop and maintain PTSD. One of the primary features of PTSD and other similar conditions (panic disorder, agoraphobia) is avoidance behaviors. These behaviors are designed to protect the individual from the possibility of harm and the feared outcome. In doing so, patients are prevented from “challenging unrealistic beliefs and thus prevent fear extinction” (Milad, Rosenbaum, & Simon, 2014). The original conditioned fear associations remain, continuing to cause intense stress and other adverse effects both on mental and physical health.

Fear conditioning laboratory tasks demonstrate how an organism can learn to fear a previously neutral stimulus by undergoing several trials in which it is paired with aversive stimuli. For example, a soldier may come to associate loud explosions with a contextual threat of potential death and the trauma they experienced when at war such that they have an aversive reaction to fireworks on the Fourth of July. Generally there are three phases in laboratory-based fear conditioning paradigms: habituation (the conditioned stimulus (CS) is presented until the participant habituates and the response normalizes), acquisition (in which the aversive stimulus (UCS) is presented with the CS and the conditioned stimulus-conditioned response (CS-CR) relationship is established and learned), and extinction (in which the association made at acquisition is no longer present such that the conditioned response (CR) does not occur after repeated presentation of the conditioned stimulus (CS) without the UCS).
The first study of fear conditioning in individuals with PTSD was conducted by Orr et al. (2000). The authors looked at the association between conditionability and PTSD status. This study was based on the theory that some PTSD symptoms are seen as conditioned responses to a traumatic UCS, and some people who are more prone to acquire conditioned responses in the first place are more likely to develop such symptoms. Conditionability may then present practically and experimentally as slower extinction of the CR. Orr et al. (2000) found evidence that an aversively conditioned electrodermal response to a previously neutral stimulus was acquired more strongly in individuals with PTSD; these individuals were also more resistant to extinction. It is not clear however what the origin of this conditionability is: if it is a pre-trauma trait it would serve as a valuable vulnerability marker (Orr et al., 2000).

The amygdala, hippocampus, and PFC are all implicated in both fear conditioning and PTSD. The amygdala regulates learned fear and receives projections from the hippocampus and PFC; it is directly involved in emotion reaction regulation. Individuals with PTSD show reduced overall activation of the PFC and hippocampus, and thus reduced activation of the amygdala. This may coincide with reduced top-down control of the amygdala, possibly resulting in a hyper-responsive amygdala signal to fearful stimuli. Disordered fear regulation in PTSD and other similar disorders could be explained by this malfunction (Mahan & Ressler, 2012).

Activation of the amygdala has been shown to be positively correlated with PTSD symptom severity and self-reported anxiety. There is also a relationship between the amygdala and the medial prefrontal cortex (mPFC). The PFC often plays the role of
rationality and toning down the animal instincts of the amygdala. In individuals with PTSD, there is a reciprocal relationship between the mPFC and the amygdala: as regional cerebral blood flow at the medial frontal gyrus of the mPFC decreases, regional cerebral blood flow at the amygdala increases. Additionally, in individuals with PTSD the hippocampus, directly involved in encoding context during fear conditioning, usually has decreased volume (Shin, Rauch, & Pitman, 2006). Fear conditioning results in reduced GABAergic signaling in the BLA compared to non-fear conditioned controls (Mahan & Ressler, 2012).

These areas of the brain involved in fear conditioning are both sexually dimorphic and contain estrogen receptors, suggesting multiple means for sex differences in PTSD manifesting in reproductive-age women compared to men. Milad et al. (2006) studied sex differences in fear conditioning of healthy individuals upon observing anxiety disorders being much more prevalent in women than men and women’s failure to extinguish conditioned fear in existing literature. The study looked at women in the eFP (low estrogen and progesterone), women in the late follicular phase (high estrogen, low progesterone), and men; results showed less extinction memory in healthy women in the late follicular phase compared to women in the eFP and men. In terms of neurobiology, the authors hypothesized late follicular phase women would display less extinction retention because the vmPFC, which is involved in fear conditioning and extinction retention, exhibits less responsivity during this phase. However estrogen has been shown to enhance synaptogenesis, long term potentiation, and learning and memory in a variety of hippocampal-dependent paradigms in healthy women. The authors concluded that high
estrogen at mid-cycle increases contextual generalization, which could lead to increased conditioned fear responding in the extinction context.

Milad et al. (2010) delved deeper into the matter of estradiol’s potential protective effects and found estradiol levels did not affect acquisition or extinction of conditioned fear, only facilitated extinction recall in women. However some differences emerge once studies were directed at individuals with PTSD as opposed to healthy individuals. Glover et al. (2012) examined if women with PTSD at low estrogen levels would show deficits in fear inhibition compared to women with high estrogen levels; this study confirmed gonadal hormonal status influences fear inhibition. Lebron-Milad, Graham, and Milad (2012) built on Glover et al.’s (2012) findings and sought to determine if estrogen levels influence fear extinction in women with PTSD. The study ultimately found women with PTSD and low estradiol have much higher conditioned responses during extinction and greater symptom severity compared to trauma exposed women without PTSD at high or low estrogen and women with PTSD at high estrogen, implying low estrogen might be a vulnerability factor for developing PTSD in women with trauma histories. Just as symptom severity may diminish during the high estradiol phases so may the vulnerability; conversely the low estradiol sections of the menstrual phase – namely, the mLP – may be the most vulnerable windows for developing PTSD and other anxiety disorders. While there is a strong case for estradiol playing a central role in anxiety disorders, it does not function alone and thus affects a number of other hormones, including progesterone and its metabolites and CRH.
Pineles et al. (in press) studied female trauma survivors with and without PTSD by testing them with a differential fear conditioning task in either the eFP or mLP. Skin conductance was measured to operationalize conditioned fear. Results showed a difference in extinction retention patterns at eFP and mLP in women with PTSD compared to women without PTSD. Extinction retention was better in the mLP (high estradiol, high progesterone) for women without PTSD. However, women with PTSD showed poorer extinction retention in the mLP; in this group high progesterone was also associated with poorer extinction retention. These findings underline the possibility that estrogen (and progesterone) plays a protective role in healthy women but creates a window of vulnerability in women with PTSD.

**LOUD TONES TASK**

One of the symptoms of PTSD is exaggerated auditory startle reflex (ASR), considered a result of hyperarousal. Orr, Lasko, Shalev, and Pitman (1995) found increased orbicularis oculi muscle startle response in Vietnam War veterans with PTSD when exposed to 15 loud tones, and the authors suggested the role of anxiety in this exaggerated startle. The loud tones paradigm used was based on the procedure used by Shalev et al. (1992): fifteen pure tones were generated and presented via headphones worn by the participants while they were hooked up to systems used to measure left orbicularis oculi electromyogram (EMG), skin conductance (SC), and heart rate (HR), which together were used to operationalize ASR. This procedure, which is used in the current study, is detailed in the Methods section of this paper.
Shalev, Peri, Orr, Bonn, and Pitman (1997), using the paradigm in Shalev et al. 1992, studied medication-free help-seeking trauma survivors with PTSD, male and female, and found those with PTSD to have overall higher average EMG, SC, and HR responses, indicating overall greater arousal. The study found heightened autonomic response reactivity to loud tones and an increased EMG response. Higher auditory startle reflex (ASR) responses were found to be associated with current PTSD diagnosis rather than trauma exposure. Morgan, Grillon, Lubin, and Southwick (1997) tested the “shock sensitization of startle” model of exaggerated startle in women with sexual assault-related PTSD following a different experimental paradigm: two pulse-alone trials and a prepulse plus pulse trial. The study found significant differences for left O-EMG responses, suggesting a laterality effect supported by findings of left-sided hippocampal abnormalities in civilian women with PTSD.

Metzger et al. (1999) tested if exaggerated startle in women represents trauma-induced sensitization that dissipates over time even if PTSD symptoms persist, which would suggest that ASR is more likely to occur in recent rather than chronic or lifetime PTSD. The study found women with current PTSD had significantly larger HR responses and slower SC habituation rates, though no difference was found in EMG responses. The authors thus found that the exaggerated startle reactivity persists even in spite of diminished PTSD symptomatology.

**SUMMARY AND AIMS OF CURRENT STUDY**

There is emerging evidence that PTSD in women may be influenced by the menstrual cycle and its associated fluctuating hormone levels. The mid-luteal phase may
be a window of vulnerability for development and maintenance of PTSD. A number of neurobiological structures and pathways are involved in the mechanisms that could influence PTSD symptom presentation; research points toward malfunctioning HPA axis responses to prolonged stress and other abnormalities such as deficiencies in ALLO due to malfunctioning enzymes in progesterone metabolism. Inherent to some of these structures is sexual dimorphism and the presence of estrogen receptors that may predispose women to the demonstrated higher vulnerability to development of anxiety disorders. Fear conditioning studies have shown stronger acquisition of aversively conditioned responses to neutral stimuli and greater resistance to extinction in individuals with PTSD. Women with PTSD showed significantly larger HR responses and slower SC habituation to a loud tones task compared to trauma control healthy participants (Metzger et al, 1999) and significant differences in left orbicularis EMGR compared to controls (Morgan, Grillon, Lubin, & Southwick, 1997).

The current study investigated if the phase of the menstrual cycle affects performance on the loud tones task in women with PTSD. The following were the hypotheses for this study:

1. Women with PTSD will display greater reactivity (higher EMGR, HRR, and SCR) in response to the loud tones task than women in the trauma-exposed control group.

2. Menstrual phase (eFP or mLP) will moderate the relationship between PTSD and performance on the loud tones task such that the difference in
reactivity (i.e., (higher EMGR, HRR, and SCR) between women with and without PTSD will be greater in the mLP as compared to the eFP.

Figure 4: Hypothesized relationship between PTSD and increased reactivity, moderated by menstrual cycle phase.

SPECIFIC AIMS

The literature supports the sex differences in the way PTSD manifests in women and that the menstrual cycle hormones interact with the compounds and brain structures involved with PTSD. The specific aims of this study are:

1. To determine if PTSD in women promotes reactivity to the loud tones task, as previous studies have shown
2. To determine if this reactivity varies depending on the phase of the menstrual cycle during testing
Determining if the menstrual cycle contributes to the blatant sex differences in how frequently trauma-exposed women develop PTSD and for how long the symptoms last would be a valuable insight that could contribute to the way these women are treated for their PTSD. Recovery from the trauma experienced is key for these women to be able to go through daily life without the hindrances imposed by PTSD. While this study does not look at the underlying neurobiological mechanisms directly, inferences can be drawn regarding which hormones and brain structures are involved, given the evidence for such connections in prior studies.
METHODS

PARTICIPANTS

Forty-six women who experienced a traumatic event participated in the current study. There were two groups of participants: women with PTSD (PTSD) ($n = 22$) and women exposed to trauma without PTSD (trauma control) ($n = 24$). Participants ranged in age from 19 to 49 years, $M = 32.15$; peri- and post-menopausal women were excluded.

For inclusion in the PTSD group, participants needed to meet criteria for current PTSD. Participants in the trauma control group experienced a traumatic event but did not meet the criteria for lifetime or current PTSD or any current Axis I disorders with the exception of specific phobia. Additional exclusion criteria included current infectious illnesses, current or history of organic brain disorder, major neurological problems, endocrine disorders, schizophrenia, psychotic disorder, bipolar disorder, current active substance dependence, hearing impairment for 1000 Hz tones or white noise, irregular menstrual cycle, current participation in active-trauma focused psychotherapy, and use of psychotropic medications, oral contraceptives, or other medications with potential effects on the tasks or hormones being measured. Participants needed to be free of alcohol or illicit drugs for two weeks.

SYMPTOMATIC ASSESSMENTS AND PSYCHOMETRY

Clinician-Administered PTSD Scale for DSM-IV (CAPS) (Blake, Weathers, Nagy, Kaloupek, Gusman, Charney, & Keane, 1995). The CAPS is a semi-structured interview conducted by a mental health professional to determine current PTSD diagnosis, lifetime PTSD diagnosis, and recent symptoms. The CAPS is the gold standard
for PTSD diagnosis. Patients are asked to keep up to three traumatic events in mind throughout the duration of the assessment. Participants are assessed for the possible presence of the 17 symptoms of PTSD. If a symptom is present, the interviewer queries the participant about the duration and severity of the symptom. After each symptom is assessed, the duration of symptoms, the participant’s subjective distress and how the PTSD symptoms impact functioning are examined. There are several versions of CAPS: past week, past month, and worst month (lifetime) (Blake, et al., 1995). For the current study, past month and lifetime were assessed.

Symptom frequency and symptom intensity are rated on Likert-style scales with responses ranging from 0 to 4. Diagnostic scores can be determined following 9 different scoring rules from which the appropriate rules for the situation are selected. These rules were studied and detailed by Weathers, Ruscio, and Keane, 1999. A commonly used scoring rule for counting a symptom is 1 or more frequency symptoms and 2 or more intensity symptoms. A diagnosis is made if there is at least 1 B symptom, 3 C symptoms, and 2 D symptoms as well as meeting the other diagnostic criteria (“CAPS Instruction Manual”, 2015). In this study, participants who endorsed at least 1 B symptom, 3 C symptoms, and 2 D symptoms and achieved a CAPS score greater than 40 qualified for the PTSD group. The no PTSD group/trauma control had CAPS scores lower than 40 and did not meet criteria for lifetime, current, or past PTSD.

**Structured Clinical Interview for DSM-IV Axis 1 Disorders (SCID-1)** (First, Spitzer, Gibbons, & Williams, 2002). SCID-1 is a diagnostic exam for major DSM-IV Axis 1 disorders. It is a widely used assessment in the form of a semi-structured
interview, performed by a mental health professional. There are several versions of SCID-1, including ones for clinical and research purposes (“SCID Frequently Asked Questions”, 2015). This study used the clinical version of SCID-1. The SCID was used in the current study to assess for inclusion exclusionary criteria and to characterize the sample with regard to comorbid diagnoses.

State-Trait Anxiety Inventory (STAI) (Speilberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). STAI is an assessment of state and trait anxiety used in clinical settings. There are 20 items each for state and trait anxiety, the former indicating current feelings of anxiety and the latter indicating more chronic feelings. Items are graded on a four-point Likert scale. Higher scores indicate higher anxiety (The State-Trait Anxiety Inventory (STAI), n.d.). This study used STAI-Trait.

PTSD Checklist (PCL) (Weathers, Litz, Herman, Huska, & Keane, 1993). The PCL is a 17-item self-report of DSM-IV PTSD symptoms used to characterize PTSD symptom severity. Responses are given on a 1-5 Likert-like scale. There are there versions of PCL: military, civilian, and specific (“Using the PTSD Checklist for DSM-IV (PCL)”, 2014). This study used the civilian version, PCL-C.

Traumatic Life Events Checklist (TLEC) (Kubany, Leisen, Kaplan, Watson, Haynes, Owens, & Burns, 2000). The TLEC is a 17-item self-report questionnaire designed to screen for potentially traumatic life events by assessing exposure to 16 events that could potentially meet criteria for a trauma as defined by DSM-IV. Response options are the following: Happened to me, Witnessed it, Learned about it, Not Sure, and Doesn’t apply. There are three versions of TLEC: standard (to determine if a traumatic event was
experienced), extended (to establish the worst event if more than one occurred), and interview (to determine if Criterion A for PTSD is met) (“Life Events Checklist for DSM-5 (LEC-5)”, 2015). This study used the standard version of TLEC.

**Beck Depression Inventory (BDI) (Beck, Steer, & Brown, 1996).** The BDI is a 21-item self-report measuring characteristic attitudes and symptoms of depression, the most recent version being the BDI-II. Responses are made using a 0-3 Likert-like scale. Scores range from 0 to 63; higher scores indicate more severe depressive symptoms (*Beck Depression Inventory (BDI)*, n.d.).

**Childhood Trauma Questionnaire (CTQ) (Bernstein, Fink, Handelsman, Foote, Lovejoy, Wenzel, Sapareto, & Ruggiero, 1994).** The CTQ is a 28-item self-report questionnaire used to rate the severity of six types of traumatic childhood events: death, divorce, violence, sexual abuse, illness, or other. Responses are given using a 5 point Likert scale. It can be administered to adolescents age 12 and over and to adults (Measurement Instrument Database for the Social Sciences, n.d.).

**PROCEDURES**

**Session 1 and 2.** After providing informed consent, participants’ height and weight were measured. Prior to testing, participants were asked to abstain from caffeine after 10am. Smokers were included in the study but were asked to abstain from cigarettes for one hour before coming in for the session. Participants were asked to provide a urine sample for a drug screen, cotinine levels to measure overall intensity of smoking, a pregnancy test indicated by urine human chorionic gonadotropin, and urinalysis. Participants were seated for 20 to 30 minutes during which a medical, psychiatric, and
substance abuse history was taken. Blood samples were also collected for routine laboratory tests and DNA testing. A hearing test and physical exam was conducted by a physician or physician’s assistant. All participants were assessed by the Structured Clinician Interview for DSM-IV Axis I Disorders (SCID-I) and the Clinician Administered PTSD Scale (CAPS). Other assessments included Beck Depression Inventory (BDI), Childhood Trauma Questionnaire (CTQ), Traumatic Life Events Checklist (TLEC), State-Trait Anxiety Inventory (STAI), and PTSD Checklist for Civilians (PCL-C). Participants completed the self-report-style psychometric assessments, including CTQ, TLEC, BDI, PCL-C, and STAI-Trait, and were interviewed for CAPS and SCID.

Participants were assigned in a pseudorandom manner to the menstrual phase during which they would first be tested. Half of the women first completed the loud tones task during the mid-luteal phase (mLP) of the menstrual cycle while the other half completed the task during the early follicular phase (eFP) in the first session, and then again in the other phase in the second session. These phases were chosen specifically for displaying the highest degree of contrast in progesterone and estradiol levels (low levels at eFP and high levels at mLP). In total each participant was tested twice, once in each phase.

**Menstrual cycle monitoring and test scheduling.** Testing during eFP was scheduled for two to six days after the start of menstruation, when progesterone and estrogen levels are low and stable. To schedule testing during mLP, a urine test kit was used to determine the day of the LH surge during the middle of the cycle, which occurs...
about 24 hours prior to ovulation and the start of the luteal phase. Participants were instructed which days to use the kit and were reminded by phone to do so and to call when the LH surge occurred so the testing could be scheduled 6-10 days later, when estrogen and progesterone levels are highest and most stable. Phase was confirmed at the time of testing by measuring progesterone and estrogen levels.

**Sessions 3 and 5.** At the time of testing an IV was inserted into the participant’s antecubital vein. After a 20 minute rest period, blood samples were collected; estradiol and progesterone levels were assayed to confirm menstrual phase. Participants then performed the loud tones task.

**Sessions 4 and 6.** A task not included in the current study was administered to the participants in sessions 4 and 6.

**STIMULI**

Stimuli consisted of fifteen 95 dB, 1000 Hz tones presented for 500ms with less than 1ms rise and fall times. Duration of intertrial intervals was randomly selected by a computer, ranging from 27 to 52 seconds.

**Procedure.** Participants were seated upright in a sound attenuated room connected to an experimental control room by wires. Once electrodes were applied to the participant, they were instructed they would have 5 minutes of relaxation time and would be followed by the loud tones task. Headphones were placed on the participant. At the conclusion of the relaxation time, the participant heard a series of loud tones, controlled by the technician in the control room. Data regarding physiologic measures was collected.
beginning 4 seconds prior to presentation of a tone at 1000 Hz and stopped 8.5 seconds after the tone.

**PHYSIOLOGIC MEASURES**

During the loud tones task, several physiologic measures were used to operationalize physiological reactivity: left orbicularis oculi electromyogram (O-EMG), skin conductance (SC), and heart rate (HR). O-EMG was measured by 4-mm Beckman-type Ag/AgCl surface electrodes filled with electrolyte paste to be placed over the left orbicularis oculi muscle. HR was measured by standard limb electrocardiogram leads. O-EMG and HR were amplified and filtered by the Coulbourn Isolated Bioamplifier with filter parameters set at 90-1000 Hz and 10ms integration time constant. SC response was measured directly by a Coulbourn Isolated Skin conductance coupler.

**RESPONSE DEFINITIONS**

O-EMG response scores (O-EMGR) were calculated for each trial by subtracting the mean O-EMG level during the 100ms immediately prior to tone onset from the highest O-EMG level within 20-120 milliseconds following the tone. The mean of the fifteen O-EMGRs was calculated for each of the participants, and then treated by a square-root transformation. A more positive O-EMGR indicates greater startle reactivity to the tones. HR response score (HRR) and SC response score (SCR) were calculated similarly within 1 second prior and 1-4 seconds after the tone. Mean HRR and SCR were calculated for each participant. More positive HRR and SCR scores indicate greater HR and SC reactivity. HR means, SC means, and EMG means were used in the analyses.
Additionally, the rate of habituation across the 15 trials was calculated and operationalized as the slope for HR, SC, and EMG. Finally, for SC and EMG, a value was specified for each measure as the point at which habituation was reached (two trials in a row with a response greater than or equal to 0.05 for SC, two trials in a row with a response greater than or equal to 0.6 for EMG) and the number of trials to this habituation marker was recorded.
RESULTS

Data Analyses

A series of 2 (PTSD: PTSD or no PTSD) x 2 (Menstrual Phase: eFP or mLP) x 2 (Order: eFP or mLP first) repeated-measures ANOVAs were conducted on means and habituation rates of skin conductance (SC), heart rate (HR), and left orbicularis electromyogram (EMG) as well as time to habituation for SC and EMG for a total of eight RM-ANOVAs.

Demographics

The majority of participants was non-Hispanic African American women with some college education and unemployed without being enrolled in school. Most participants were never married and non-smokers. There were no significant differences between the PTSD and trauma control groups on the demographic variables (see Table 1).

There were significant differences between the PTSD group and the trauma control group for all of the psychologic assessment measures \( (p < 0.001) \) (see Table 2). Specifically, the PTSD group scored higher on measures of PTSD symptom severity (as measured by the CAPS), depressive symptoms (as measured with the BDI), and trait anxiety (as measured with the STAI-Trait).

The SCID-I was used to assess the presence of current axis 1 disorders (see Table 3). More individuals within the PTSD group qualified for an anxiety or mood disorder as compared to the trauma control group.
### Table 1. Participant Demographics

<table>
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<th>Trauma Control</th>
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</tr>
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<td>1</td>
</tr>
<tr>
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Table 2. **Symptom and Psychologic Assessments**

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<td>SD</td>
<td>M</td>
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<td>PTSD Scale (CAPS)</td>
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<td>Trait Anxiety (STAI -)</td>
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<td>Trait</td>
<td>Total</td>
<td>PTSD</td>
<td>Trauma</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----------</td>
<td>------------</td>
<td>-----------</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
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<tr>
<td>Depression (BDI)</td>
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<td>Traumatic Life Events (TLEC)</td>
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<td>Childhood Trauma (CTQ)</td>
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**Table 3. Current Axis 1 Disorders**

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<th>Trauma</th>
<th>Control</th>
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<td>n</td>
<td>%</td>
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<td>4.3</td>
<td>20</td>
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</table>
ANOVA Results

Bolded lines indicate statistically significant effects (p<0.05). Italicized lines indicate trends (p<0.1).

Heart Rate.

Mean. There was a significant main effect of Menstrual Phase, $F(1,35) = 5.851, p = 0.021$ (see Table 4). Participants in the eFP exhibited lower mean heart rates, $M = 1.375$ s$^{-1}$, $SD = 0.154$, than participants in the mLP, $M = 1.793$, $SD = 0.149$.

Table 4. Mean Heart Rate

<table>
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<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Partial $\eta^2$</th>
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<td>Menstrual Phase</td>
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<td>5.851</td>
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<td>Order</td>
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<td>1.057</td>
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<td>Menstrual Phase x PTSD</td>
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<td>0.046</td>
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<td>Menstrual Phase x Order</td>
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</tr>
<tr>
<td>Order</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Slope (Rate of Habituation). There were no significant main effects or interactions of the rate of habituation of heart rate (see Table 5).
Table 5. *Heart Rate Slope*

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menstrual Phase</td>
<td>1,35</td>
<td>9.519E-5</td>
<td>9.519E-5</td>
<td>0.001</td>
<td>0.977</td>
<td>0.000</td>
</tr>
<tr>
<td>PTSD</td>
<td>1,35</td>
<td>0.044</td>
<td>0.044</td>
<td>0.475</td>
<td>0.495</td>
<td>0.013</td>
</tr>
<tr>
<td>Order</td>
<td>1,35</td>
<td>0.050</td>
<td>0.050</td>
<td>0.549</td>
<td>0.464</td>
<td>0.015</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD</td>
<td>1,35</td>
<td>0.064</td>
<td>0.064</td>
<td>0.572</td>
<td>0.455</td>
<td>0.016</td>
</tr>
<tr>
<td>Menstrual Phase x Order</td>
<td>1,35</td>
<td>0.176</td>
<td>0.176</td>
<td>1.579</td>
<td>0.217</td>
<td>0.043</td>
</tr>
<tr>
<td>PTSD x Order</td>
<td>1,35</td>
<td>0.032</td>
<td>0.032</td>
<td>0.352</td>
<td>0.557</td>
<td>0.010</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD x Order</td>
<td>1,35</td>
<td>0.122</td>
<td>0.122</td>
<td>1.094</td>
<td>0.303</td>
<td>0.030</td>
</tr>
</tbody>
</table>

**Skin Conductance.**

**Mean.** Although not statistically significant, it is notable that the main effect of Menstrual Phase approached statistical significance, $F(1,23) = 3.693, p = 0.067$ (see Table 6). Importantly, the pattern of results was opposite to that of heart rate. Specifically participants in the eFP exhibited higher mean skin conductance response, $M = 0.333$, $SD = 0.850$, than participants in the mLP, $M = 0.223$, $SD = 0.053$. 

Table 6. *Mean Skin Conductance*

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menstrual Phase</td>
<td>1,23</td>
<td>0.156</td>
<td>0.156</td>
<td>3.693</td>
<td>0.067</td>
<td>0.138</td>
</tr>
<tr>
<td>PTSD</td>
<td>1,23</td>
<td>0.079</td>
<td>0.079</td>
<td>0.356</td>
<td>0.557</td>
<td>0.015</td>
</tr>
<tr>
<td>Order</td>
<td>1,23</td>
<td>0.021</td>
<td>0.021</td>
<td>0.094</td>
<td>0.762</td>
<td>0.004</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD</td>
<td>1,23</td>
<td>0.032</td>
<td>0.032</td>
<td>0.761</td>
<td>0.392</td>
<td>0.032</td>
</tr>
<tr>
<td>Menstrual Phase x Order</td>
<td>1,23</td>
<td>0.052</td>
<td>0.052</td>
<td>1.232</td>
<td>0.279</td>
<td>0.051</td>
</tr>
<tr>
<td>PTSD x Order</td>
<td>1,23</td>
<td>0.016</td>
<td>0.016</td>
<td>0.073</td>
<td>0.789</td>
<td>0.003</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD x Order</td>
<td>1,23</td>
<td>0.039</td>
<td>0.039</td>
<td>0.929</td>
<td>0.345</td>
<td>0.039</td>
</tr>
</tbody>
</table>

*Slope (Rate to Habituation).* There were no statistically significant main effects or interactions (see Table 7).

Table 7. *Skin Conductance Slope*

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menstrual Phase</td>
<td>1,23</td>
<td>0.079</td>
<td>0.079</td>
<td>0.871</td>
<td>0.360</td>
<td>0.036</td>
</tr>
<tr>
<td>PTSD</td>
<td>1,23</td>
<td>0.342</td>
<td>0.342</td>
<td>1.141</td>
<td>0.297</td>
<td>0.047</td>
</tr>
<tr>
<td>Order</td>
<td>1,23</td>
<td>0.047</td>
<td>0.047</td>
<td>0.156</td>
<td>0.697</td>
<td>0.007</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD</td>
<td>1,23</td>
<td>0.000</td>
<td>0.000</td>
<td>0.002</td>
<td>0.964</td>
<td>0.000</td>
</tr>
<tr>
<td>Menstrual Phase x Order</td>
<td>1,23</td>
<td>0.312</td>
<td>0.312</td>
<td>3.448</td>
<td>0.076</td>
<td>0.130</td>
</tr>
<tr>
<td>PTSD x Order</td>
<td>1,23</td>
<td>0.033</td>
<td>0.033</td>
<td>0.109</td>
<td>0.744</td>
<td>0.005</td>
</tr>
</tbody>
</table>
Trials to Habituation. There was a significant interaction of Menstrual Phase and Order, $F(1,23) = 5.335, p = 0.030$ (see Table 8). Participants who were first tested in the follicular phase at session 3 took more trials on average to reach habituation in the follicular phase, $M = 6.143, SD = 1.306$, compared to the luteal phase in session 5, $M = 3.857, SD = 1.196$. Participants who were first tested in the luteal phase in session 3 took more trials on average to reach habituation in the luteal phase, $M = 5.300, SD = 1.276$, than in the follicular phase in session 5, $M = 3.787, SD = 1.393$.

Table 8. Skin Conductance Trials to Habituation

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menstrual Phase</td>
<td>1,23</td>
<td>1.958</td>
<td>1.958</td>
<td>0.221</td>
<td>0.643</td>
<td>0.010</td>
</tr>
<tr>
<td>PTSD</td>
<td>1,23</td>
<td>11.273</td>
<td>11.273</td>
<td>0.332</td>
<td>0.576</td>
<td>0.014</td>
</tr>
<tr>
<td>Order</td>
<td>1,23</td>
<td>2.727</td>
<td>2.727</td>
<td>0.078</td>
<td>0.783</td>
<td>0.003</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD</td>
<td>1,23</td>
<td>7.777</td>
<td>7.777</td>
<td>0.878</td>
<td>0.358</td>
<td>0.037</td>
</tr>
<tr>
<td><strong>Menstrual Phase x Order</strong></td>
<td><strong>1,23</strong></td>
<td><strong>47.244</strong></td>
<td><strong>47.244</strong></td>
<td><strong>5.335</strong></td>
<td><strong>0.030</strong></td>
<td><strong>0.188</strong></td>
</tr>
<tr>
<td>PTSD x Order</td>
<td>1,23</td>
<td>19.343</td>
<td>19.343</td>
<td>0.552</td>
<td>0.465</td>
<td>0.032</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD x Order</td>
<td>1,23</td>
<td>1.532</td>
<td>1.532</td>
<td>0.173</td>
<td>0.681</td>
<td>0.007</td>
</tr>
</tbody>
</table>
Left Orbicularis Electromyogram.

**Mean.** There was a significant main effect of PTSD, $F(1,31) = 5.264$, $p = 0.029$ (see Table 9). Counter to our hypotheses, participants with PTSD demonstrated lower mean EMGR, $M = 3.046$, $SD = 0.511$, than participants without PTSD, $M = 4.624$, $SD = 0.460$.

There was also a significant interaction of Menstrual Phase by Order, $F(1,31) = 6.034$, $p = 0.020$ (see Table 6). Participants who were first tested in the follicular phase at session 3 had higher mean EMGR in the follicular phase, $M = 4.167$, $SD = 0.439$, compared to in the luteal phase at session 5, $M = 3.786$, $SD = 0.518$. Participants who were first tested in the luteal phase at session 3 had higher mean EMGR in the luteal phase, $M = 4.314$, $SD = 0.640$, than in the follicular phase at session 5, $M = 3.073$, $SD = 0.542$.

**Table 9. Mean EMG Response**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>$F$</th>
<th>$p$</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menstrual Phase</td>
<td>1,31</td>
<td>3.067</td>
<td>3.067</td>
<td>1.696</td>
<td>0.202</td>
<td>0.052</td>
</tr>
<tr>
<td><strong>PTSD</strong></td>
<td>1,31</td>
<td><strong>41.257</strong></td>
<td><strong>41.257</strong></td>
<td><strong>5.264</strong></td>
<td><strong>0.029</strong></td>
<td><strong>0.145</strong></td>
</tr>
<tr>
<td>Order</td>
<td>1,31</td>
<td>1.331</td>
<td>1.331</td>
<td>0.170</td>
<td>0.683</td>
<td>0.005</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD</td>
<td>1,31</td>
<td>5.155</td>
<td>5.155</td>
<td>2.850</td>
<td>0.101</td>
<td>0.084</td>
</tr>
<tr>
<td><strong>Menstrual Phase x Order</strong></td>
<td>1,31</td>
<td><strong>10.913</strong></td>
<td><strong>10.913</strong></td>
<td><strong>6.034</strong></td>
<td><strong>0.020</strong></td>
<td><strong>0.163</strong></td>
</tr>
<tr>
<td>PTSD x Order</td>
<td>1,31</td>
<td>16.712</td>
<td>16.712</td>
<td>2.132</td>
<td>0.154</td>
<td>0.064</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD x</td>
<td>1,31</td>
<td>2.293</td>
<td>2.293</td>
<td>1.268</td>
<td>0.269</td>
<td>0.039</td>
</tr>
</tbody>
</table>
**Slope (Rate to Habituation).** There were no significant main effects or interactions for EMG rate of habituation (see Table 10).

**Table 10. EMG Slope**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menstrual Phase</td>
<td>1,31</td>
<td>0.000</td>
<td>0.000</td>
<td>0.002</td>
<td>0.966</td>
<td>0.000</td>
</tr>
<tr>
<td>PTSD</td>
<td>1,31</td>
<td>0.165</td>
<td>0.165</td>
<td>1.119</td>
<td>0.298</td>
<td>0.035</td>
</tr>
<tr>
<td>Order</td>
<td>1,31</td>
<td>0.026</td>
<td>0.026</td>
<td>0.175</td>
<td>0.679</td>
<td>0.006</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD</td>
<td>1,31</td>
<td>0.007</td>
<td>0.007</td>
<td>0.065</td>
<td>0.800</td>
<td>0.002</td>
</tr>
<tr>
<td>Menstrual Phase x Order</td>
<td>1,31</td>
<td>0.083</td>
<td>0.083</td>
<td>0.773</td>
<td>0.386</td>
<td>0.024</td>
</tr>
<tr>
<td>PTSD x Order</td>
<td>1,31</td>
<td>0.053</td>
<td>0.053</td>
<td>0.360</td>
<td>0.553</td>
<td>0.011</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD x Order</td>
<td>1,31</td>
<td>0.177</td>
<td>0.177</td>
<td>1.651</td>
<td>0.208</td>
<td>0.051</td>
</tr>
</tbody>
</table>

**Trials to Habituation.** There was a significant main effect of PTSD, $F(1,31) = 4.299, p = 0.047$ (see Table 11). Participants with PTSD, $M = 10.783, SD = 0.924$, reached habituation in fewer trials than participants without PTSD, $M = 13.361, SD = 0.832$.

There was also an interaction of Menstrual Phase by PTSD that approached statistical significance, $F(1,31) = 4.135, p = 0.05$ (see Table 8). Participants without PTSD took more time on average to reach habituation in the follicular phase, $M = 13.750$,
$SD = 0.940$, compared to in the luteal phase, $M = 12.972, SD = 0.963$. Participants with PTSD took more time on average to reach habituation in the luteal phase, $M = 11.800, SD = 1.071$, compared to in the follicular phase, $M = 9.767, SD = 1.044$.

Table 11. *EMG Trials to Habituation*

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menstrual Phase</td>
<td>1, 31</td>
<td>6.527</td>
<td>6.527</td>
<td>0.824</td>
<td>0.371</td>
<td>0.026</td>
</tr>
<tr>
<td>PTSD</td>
<td>1, 31</td>
<td>110.131</td>
<td>110.131</td>
<td>4.299</td>
<td>0.047</td>
<td>0.122</td>
</tr>
<tr>
<td>Order</td>
<td>1, 31</td>
<td>11.559</td>
<td>11.559</td>
<td>0.451</td>
<td>0.507</td>
<td>0.014</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD</td>
<td>1, 31</td>
<td>32.765</td>
<td>32.765</td>
<td>4.135</td>
<td>0.051</td>
<td>0.118</td>
</tr>
<tr>
<td>Menstrual Phase x Order</td>
<td>1, 31</td>
<td>0.006</td>
<td>0.006</td>
<td>0.001</td>
<td>0.979</td>
<td>0.000</td>
</tr>
<tr>
<td>PTSD x Order</td>
<td>1, 31</td>
<td>14.388</td>
<td>14.388</td>
<td>0.562</td>
<td>0.459</td>
<td>0.018</td>
</tr>
<tr>
<td>Menstrual Phase x PTSD x Order</td>
<td>1, 31</td>
<td>2.458</td>
<td>2.458</td>
<td>0.310</td>
<td>0.582</td>
<td>0.010</td>
</tr>
</tbody>
</table>
DISCUSSION

The current study examined the relationship between PTSD in women, the menstrual cycle and its associated hormones, and performance on the loud tones task (see Table 12 for summary figure). Some of the findings of the current study support the literature such that HRR scores were higher in the mLP, indicating higher reactivity. This was not the case for SCR and EMGR. Several of the major findings were in fact surprising: participants with PTSD demonstrated lower mean EMGR scores and reached habituation in fewer trials than participants without PTSD, contrary to our expectations. Additionally, the pattern of SCR scores was the opposite that of the HRR scores: participants in the eFP exhibited higher mean SCR. These results are indicative of complicated mechanisms underlying the processes involved in this study.

We anticipated menstrual phase moderating the relationship between PTSD and performance on the loud tones task. However, the results for PTSD x menstrual phase interactions were mostly null, with one exception for EMG trials to habituation. Contrary to our hypotheses, the trauma control group on average took more trials to reach habituation than participants with PTSD in both menstrual cycle phases. However, these group differences were greater in the mid-luteal phase as compared to the early follicular phase. This partially supports the idea that the luteal phase is a period of vulnerability for women with PTSD. For women without PTSD, high levels of estradiol could be protective, which is supported by the trauma controls performing worse (requiring more trials to reach habituation) on this task during the follicular phase. Estradiol and progesterone levels were low at the eFP, a healthy woman’s period of vulnerability, while
high levels of estradiol and progesterone in the mLP created vulnerability in women with PTSD. This fits with the aforementioned rationale regarding the different effects of estradiol and progesterone on healthy women compared to women with PTSD.

Analyses also examined the impact of order of testing, i.e., if performing the loud tones task in the follicular or luteal phase first influenced performance on the task in the second session. When participants were first tested in the follicular phase, they required more trials to reach habituation for SCR when in the follicular phase than in the luteal phase in the second session. When participants were tested in the luteal phase first, they required more trials to reach habituation for SCR in the luteal phase than the follicular. The same pattern was observed for mean EMGR scores: participants tested first in the follicular phase had higher mean EMGR in the follicular phase than in the luteal phase in the second session, and participants tested in the luteal phase first had higher mean EMGR in the luteal phase than in the follicular phase in the second session. These effects may have been due to the unfamiliarity of the task in the first session and subsequent preparedness for the second session.

Table 12. Summary of Results

<table>
<thead>
<tr>
<th>Measure</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Heart Rate Response</td>
<td>Participants had lower average heart rate reactivity to loud tones in the eFP than the mLP</td>
</tr>
<tr>
<td>Mean Skin Conductance</td>
<td>Participants had higher mean skin conductance reactivity in the eFP than the mLP, the opposite effect as with mean heart rate</td>
</tr>
<tr>
<td>Skin Conductance Trials to Habitation</td>
<td>Participants were more reactive and took more trials to reach habituation in session 3 compared to session 5</td>
</tr>
</tbody>
</table>
| Mean EMGR                   | • Participants with PTSD were less reactive (lower mean EMGR) compared to participants in the trauma control group, contrary to our hypothesis  
• Participants tested in eFP first were more reactive (higher mean EMGR) in session 3 than mLP in session 5; participants |
tested in mLP first were more reactive in session 3 than in eFP in session 5

| EMG Trials to Habituation | • Participants with PTSD were less reactive (fewer trials to reach habituation) than participants in the trauma control group, contrary to our hypothesis  
• Participants with PTSD were more reactive in the mLP and took more time to reach habituation than in the eFP; participants in the trauma control group were more reactive in the eFP compared to the mLP |

A number of factors may have contributed to this study’s relative lack of support for our initial hypotheses. First, this study may have been underpowered due to its relatively small sample size ($n = 46$). In addition, the ethnic/racial diversity of the sample may have also contributed to our study’s mostly null results. Previous studies found African Americans are often non-responders to skin conductance testing (Inslicht et al., 2013) and considering the majority of the sample being African American the results for skin conductance may have been skewed due to this effect, in spite of clear non-responders having been removed from the sample. Perez Benitez et al. (2014) investigated PTSD in African Americans in a longitudinal study, citing higher rates of exposure to major traumatic events and higher lifetime prevalence rates of PTSD (8.7%) compared to whites (7.4%) as well as higher risk of developing PTSD (1.2 times higher compared to whites). The study found high rates of chronicity among African Americans with PTSD as well as high rates of comorbidity (such as with major depressive disorder (MDD)) and lower psychosocial functioning. These factors may also have affected performance on the loud tones task. Thus certain ethnic or demographic groups may be affected by traumatic events differently or have PTSD manifest in particular ways (such as with comorbid MDD); such patterns may have affected results as well. In future
studies with a larger sample it would be worthwhile to stratify by demographics to see if there are differing effects.

Another consideration is the type of trauma experienced by each participant and the age at which the event happened. Maerker et al. (2004) demonstrated how different types of trauma might affect an individual differently as well as the age, building off the idea that PTSD as a disorder requires a certain maturity of thinking that children might not possess. The study showed experiencing a traumatic event in childhood (before age 12) is related to higher rates of MDD than experiencing trauma as an adolescent (13 and older) while such an age-related difference wasn’t found for PTSD. Consideration of the duration of the traumatic event (chronic or an isolated incident) may also shed light on the interesting results found in this study.

There are likely individual differences in PTSD symptom profiles. While hyperarousal is one of four primary symptoms, as with any condition there can be variance in the way the condition manifests. Some participants in the PTSD group may not have been as affected by hyperarousal as, for example, the re-experiencing symptoms and thus did not perform as poorly on the loud tones task as other members of the group. The contributions of psychosocial and environmental factors as well as comorbidity may affect how PTSD manifests in a given individual and thus how they perform on assessments like the loud tones task.

Pietrzak et al. (2014) examined typologies of PTSD in the US adult population, finding three broad categories: Anxious-Re-experiencing, Dysphoric, and High Symptom. There were demographic differences between the categories: members of the
High Symptom group were more likely to be younger, Black or Hispanic, less educated, and having a lower income while those in the Anxious-Re-experiencing group were more likely to be Hispanic, less educated, and less likely to be widowed/separated/divorced. The authors ultimately suggest the nature of the trauma exposure is associated with different manifestations of PTSD symptoms – that certain exposures may give rise to unique clusters of symptoms that may be etiologically linked to the nature of the traumatic event (for instance, sexual assault, military combat was most often found in the Anxious-Re-experiencing group while loss of a loved one was most common in the Dysphoric group).

Related to this is the idea of different phenotypes of PTSD on a molecular level. A problem in ALLO conversion and in the HPA axis or CRH functioning are contenders for underlying mechanisms of PTSD but they are not the only ones; another compound that may contribute to this is neuropeptide Y (NPY), which plays a role in anxiety and depression by contributing to maintaining emotional homeostasis (Heilig, 2004) by acting as an anxiolytic (Thorsell, 2010). NPY is in part regulated by estrogen via membrane-bound ERα-mediated signaling at hypothalamic NPY-synthesizing neurons, which leads to NPY inhibition (Dhillon & Belsham, 2011). It follows that high estrogen would inhibit NPY and subsequently reduce some of its anxiolytic effects and contribute to the imbalance of emotional homeostasis at points of the menstrual cycle when estrogen is high (the mLP). In addition, estradiol modulates CRH by binding at the PVN to an ERα/ERβ-cAMP regulatory element that result in upregulation of CRH mRNA (Lalmansingh & Uht, 2008). Considering the potentially protective effects of estrogen in
healthy women, this effect may only be valid in an individual whose emotional homeostasis is already imbalanced – an individual, for example, with PTSD.

For some individuals with PTSD there may be a problem with ALLO, and in others it might be NPY, or CRH. In others, it might be a combination of molecular problems. While there are a number of possible mechanisms underlying PTSD, it is unclear if these are acquired malfunctions due to the traumatic event or inherent individual differences that created a window of vulnerability. Knowing the answer to this question would open up many avenues of therapy and treatment. However this is a comparatively far-off goal in the trajectory of PTSD research, given where we are at the present time and what remains to be understood first.

Limitations of this study include: small sample size, the use of a traumatized control group as opposed to a healthy control group, the use of only two menstrual phases, characteristics of the sample, and that the DSM-IV-TR criteria (which was current at the time the data was collected) was used as opposed to the more recent DSM-5.

Future avenues of research should include continuing to try and understand the significance of ALLO, the HPA axis, and the hormones involved in the menstrual cycle with regard to PTSD manifestation and symptom severity. Similar studies could be conducted on other symptoms attributed to PTSD in order to determine how women specifically are affected. Further investigation into the menstrual cycle and menstrual hormones with regard to the presentation of PTSD symptoms is needed by testing women at a variety of points in the cycle. Replication of these results with a larger and more
diverse sample is needed in order to ascertain if these results are replicable. Such studies should also adjust for changes in diagnostic criteria in the DSM-5. Future studies should look longitudinally at performance on the loud tones tasks between the fifteen tones and across multiple sessions. Future research also should examine the difference in performance on loud tones tasks between healthy individuals and trauma exposed individuals without a PTSD diagnosis.

Additionally considering demographic studies and points mentioned here, it would be prudent to pursue studying more specific samples, such as African American women, inhabitants of specific communities and neighborhoods, and individuals exposed to specific types of trauma. If the ultimate goal is to improve treatment for individuals with PTSD as well as to understand how the disorder manifests, the research indicates a need to further investigate why PTSD affects certain groups of people disproportionately. It would also be beneficial to further investigate how specific types of trauma and duration of trauma exposure affect PTSD symptom presentation.

There is limited evidence that menstrual cycle may moderate the association between PTSD and habituation of the O-EMG response on the loud tones task. There was somewhat more support for the impact on menstrual phase on reactivity across women with and without PTSD. Interestingly, the opposing pattern of results for heart rate and skin conductance suggest that sympathetic and parasympathetic reactivity may be differentially affected my menstrual cycle phase. Further research needs to be done in order to better understand the relationship between PTSD and the menstrual cycle,
particularly in consideration of the hormones involved in relation to timing of trauma and the laboratory experimentation.
REFERENCES


Systems that Promote PTSD-Like Startle Abnormalities. *Journal of Neuroscience*, 35 (42), 14270-14285.


CURRICULUM VITAE

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Education
Boston University School of Medicine
Graduate Medical Sciences Division
MS in Medical Sciences (anticipated graduation: 2016)
August 2014 - Present

New York University in London, UK
January 2012 – May 2012

New York University
August 2010 – May 2014
Bachelor of Arts in Psychology; Pre-Med track
Minors in Medieval and Renaissance Studies and Physics

Volunteer Experience
VA Boston – National Center for PTSD
Jamaica Plain, MA
Research Assistant
October 2015 – Present

- Worked on Master’s Thesis (“Trauma and Psychophysiological Reactivity”) under the supervision of Dr. Suzanne Pineles
- Ran data analyses using SPSS, R
- Managed data for large studies
- Helped write papers, research grant proposals, and presentations

Beth-Israel Hospital – Philips Ambulatory Care Center
New York, NY
Post-Op Recovery Room Volunteer
October 2013 – February 2014

- Stripped charts, entered patient information at nurse’s station
- Retrieved patients’ belongings, escorted patients in wheelchairs out of hospital
- Performed tasks and ran errands for the nurses; delivered/retrieved charts to and from Pre-Op and Post-Op

The Motivation Lab at NYU
New York, NY
Research Assistant
January 2013 – May 2014

- Operated multiple psychophysiological experiments with BioPac
- Acted as experimenter for multiple psychophysiological experiments
- Performed scheduling and recruiting; contacted participants following sign-up regarding experimental protocol; managed scheduling conflicts
- Organized information regarding past experiments and participants
- Performed data entry, coded experimental results for analysis
VIDA Volunteer Travel

Nicaragua and Costa Rica

January 2012

Medical Volunteer

- Worked in free clinics in Costa Rica and Nicaragua
- Helped local physicians diagnose and treat patients
  - Worked in groups to assess patients’ symptoms and differentially diagnose their conditions, gathered information on vital signals and medical history
  - Presented personal information, symptoms, and diagnoses to a physician for each patient
  - Explained to patient how to use the medicines prescribed by the physician
  - Worked the pharmacy station by filling prescriptions

St. Francis Hospital

Poughkeepsie, NY

Emergency Room Volunteer

July 2011 – August 2011

- Organized and cleaned EMT storage room
- Kept patient and trauma rooms clean and stocked; stripped and redressed beds, restocked blanket incubator

Work Experience

Rosie’s Place

Roxbury, MA

October 2015 – Present

- Worked at the front desk with other employees
  - Answered phone calls, took messages, processed incoming mail, sent faxes, made copies, provided information and help to women at the shelter
- Worked in the food pantry with other employees
  - Input information of women using the service, trained and supervised volunteers, kept the pantries organized and well-stocked, processed deliveries, cleaned and locked up pantries at the end of the night
- Occasionally worked with the Outreach Van on trips to Roxbury, Dorchester, and other neighborhoods
  - Distributed clothes, toiletries, water, snacks, blankets, coats
  - Provided information about the services at Rosie’s Place to women who came to the Van

Research

VA Boston – National Center for PTSD (Jamaica Plain)

October 2015 – Present

- Master’s Thesis: “Trauma and Psychophysiological Reactivity”
  - Examining how PTSD in women is affected by menstrual phase with regard to performance on loud tones task as an operationalization of startle reactivity
- Principle investigator: Dr. Suzanne L. Pineles

NYU Department of Psychology

October 2013 – May 2015

- Course: Lab in Social and Personality Psychology
  - In a small group conducted correlational archival study of visual representations of American politicians of color by national news sources
  - Wrote scientific paper on findings, presented to class
Continued social psychology research at NYU during Spring 2014 studying media bias and representations of skin tone of politicians of color, previously studied in Lab in Social and Personality, in the Social Perception, Action, and Motivation Lab

- Research team granted the Dean’s Undergraduate Research Fund Grant in Spring 2014

- Team gave talk on research findings at NYU Undergraduate Research Conference in April 2014, was awarded for Best Panel

- Team gave talk on research findings at NYU Summer Student Conference sponsored by the NYU Arts & Sciences Diversity Initiative

- Research project ongoing at NYU; plan to seek publication of findings in the near future

### Awards

- Dean’s List for Academic Year: 2013 – 2014
- Dean’s Undergraduate Research Fund Grant for Spring 2014
- NYU Undergraduate Research Conference 2014: Best Panel

### Presentations


### Publications


### Other Experiences

#### Clinical

- Shadowing
  - Summer 2011
    - Shadowed local physicians in multiple fields of medicine at St. Francis Hospital and Vassar Brothers Hospital in Poughkeepsie, NY

#### Languages

- Fluent in Romanian: native speaker
- Knowledge of Spanish: took university-level courses up to/including Intermediate II; used Spanish language knowledge in clinical work during VIDA Volunteer service trip to Central America

#### Memberships

- NYU division of the American Medical Students Association
- Boston Student Health Activist Community

#### Skills

- Excellent communication and writing skills
- Experience working in group settings and in one-on-one interactions in professional and academic settings
- Academic writing: have written scientific papers in APA and MLA formats for psychology and biology as well as papers in non-scientific disciplines
- Statistics: Excel, SPSS; currently learning R
- Highly critical reader of information
- Creative writing: self-published fiction novel in Fall 2006; writes novels, short stories in spare time
- Other interests: history, movies and TV, books, writing, literature, art, social justice and activism, bubble tea