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Differences in sympathetic nervous response due to gender

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DIFFERENCES IN SYMPATHETIC NERVOUS RESPONSE DUE TO GENDER

by

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ABSTRACT

The sympathetic nervous system, in addition to its many roles as part of the autonomic nervous system, utilizes contact with many organs in the body to recruit them for an immediate response to danger. The multiple survival responses that the sympathetic nervous system manifests are typically known as the fight, flight or freeze response. The freeze response, otherwise referred to as tonic immobility, is being explored here for its survival value in the specific context of gender. It is our belief that in situations of interpersonal aggression, females may be more suited to survive by utilizing a tonic response when they are confronted with violence. Research in the areas of both tonic immobility and gender differences will be explored and compared, as well as animal origins of tonic immobility. It is our hope that by looking at the various studies already conducted on these topics, a path for future research on gender and sympathetic response may be illuminated in the field of physiological psychology.

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ABBREVIATIONS

ANS	Autonomic nervous system
ACTH	Adrenocorticotropic hormone
CFA	Confirmatory Factor Analysis
CRH	Corticotropin-releasing hormone
CSA	Childhood sexual abuse
EFA	Explanatory Factor Analysis
ETI	Early trauma index
HPA axis	Hypothalamic-pituitary-adrenal axis
LEQ	Life Experiences Questionnaire
MLE	Maximum Likelihood Estimation
PDS	Posttraumatic Diagnostic Scale
PTSD	Post-traumatic stress disorder
PPTSD-R	The Purdue Posttraumatic Stress Disorder Scale-Revised
SAM	Sympathetic-adrenal-medullary system
SNS	Sympathetic nervous system
TEQ	Traumatic events questionnaire
TI	Tonic immobility
TIS	Tonic Immobility Scale
TIS-C	Tonic Immobility Scale- Child Form
TSST	Trier Social Stress Test

Introduction

The Anatomy and Physiology of Stress

Stress is the constant reality of every living creature. Because of this reality, life is sustained by constantly regulating how the body copes with various natural situations such as thirst, hunger, fear, arousal, and temperature changes. There are many mechanisms to maintain a stable internal environment, otherwise known as homeostasis, within our bodies. A very important organ involved in homeostasis is the hypothalamus. The hypothalamus is located along the walls of the third ventricle at the base of the brain and it works to integrate visceral and somatic responses to the needs that the brain perceives (Bear, et al., 2007). Directly below the hypothalamus lay the pituitary gland. The anterior lobe of the pituitary and the hypothalamus are closely connected and communicate to regulate the release of many different hormones, such as follicle-stimulating hormone, prolactin, luteinizing hormone, growth hormone, and adrenocorticotropic hormone (abbreviated to ACTH), which is an important hormone in stress. The daily stress response in most mammals is regulated by the hypothalamus, the anterior pituitary, and the adrenal glands (located on top of the kidneys) in a feedback system referred to as the HPA axis. There is also the immediate stress response, which involves the hypothalamus signaling the sympathetic nervous system in a sympathetic-adrenal-medullary response (abbreviated to the SAM system) that we will be exploring in greater detail throughout this paper. The adrenal cortex, a specific outer area of the adrenal glands, produces cortisol, a glucocorticoid steroid hormone which has widespread effects on the body. Cortisol, made from cholesterol, increases the levels of glucose in

the plasma, making it available for cells and enabling the body to respond to stress over a prolonged period of time, physiological, psychological or otherwise. The release of cortisol is stimulated by stress, but stress is perceived by cells in the hypothalamus which, when duress is detected, release the peptide corticotropin-releasing hormone, or CRH, which travels to the anterior pituitary that is then stimulated to release adreno-corticotropin hormone into the bloodstream. ACTH then travels to the adrenal cortex to stimulate the release of cortisol, which produces the widespread effects of the stress response. This is the mechanism of the HPA axis. Illustrations of this important mechanism can be seen below. Cortisol can act directly on the brain, and has receptors specifically in the hypothalamus. The hypothalamus also controls a more immediate response to sudden threats, the autonomic nervous system. This is closely associated with the HPA axis, as it involves the hypothalamus and similar hormones and effects, and the two are considered complementary in some ways. The autonomic nervous system is comprised of two parts, the sympathetic and parasympathetic divisions. The parasympathetic division is commonly referred to as the "rest and digest" part of the ANS, and this part works in comparative opposition to the sympathetic nervous system, which manifests the "fight or flight" response when immediate danger is detected. The sympathetic nervous systems threat response is important to our introduction here as it is a widespread reaction to stress which causes an involuntary influence that enhances survival. As we noted previously, this is commonly referred to as the sympathetic-adrenal-medullary response system, or SAM system. The SAM system response is elicited by the hypothalamus when it perceives immediate danger and it utilizes the

hormone noradrenaline, which stimulates the adrenal medulla to produce more noradrenaline and adrenaline, hormones which cause widespread physiological changes in the body which are readied in various ways to respond to the immediate threat. The behavioral response which is caused by this hypothalamic activation, the sympathetic nervous response, and how it may manifest itself depending on gender, is the focus of our topic here.

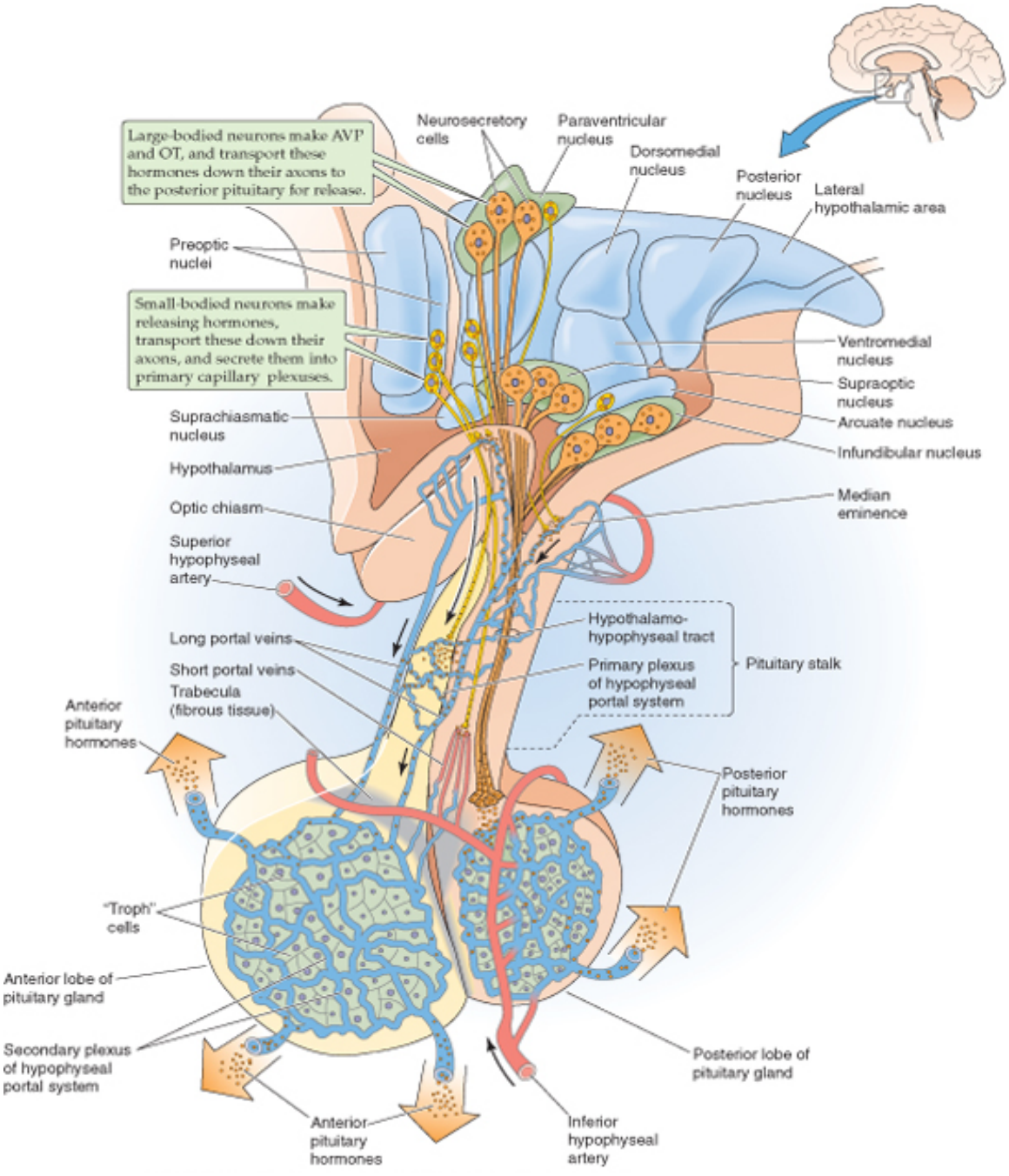

Figure 1. Hypothalamic and Pituitary Interaction. This figure shows how the hypothalamus interacts with the pituitary gland to release hormones that have widespread effects throughout the body. (Figure from *Medical Physiology* 2nd edition, Boron and Boulpaep, 2009)

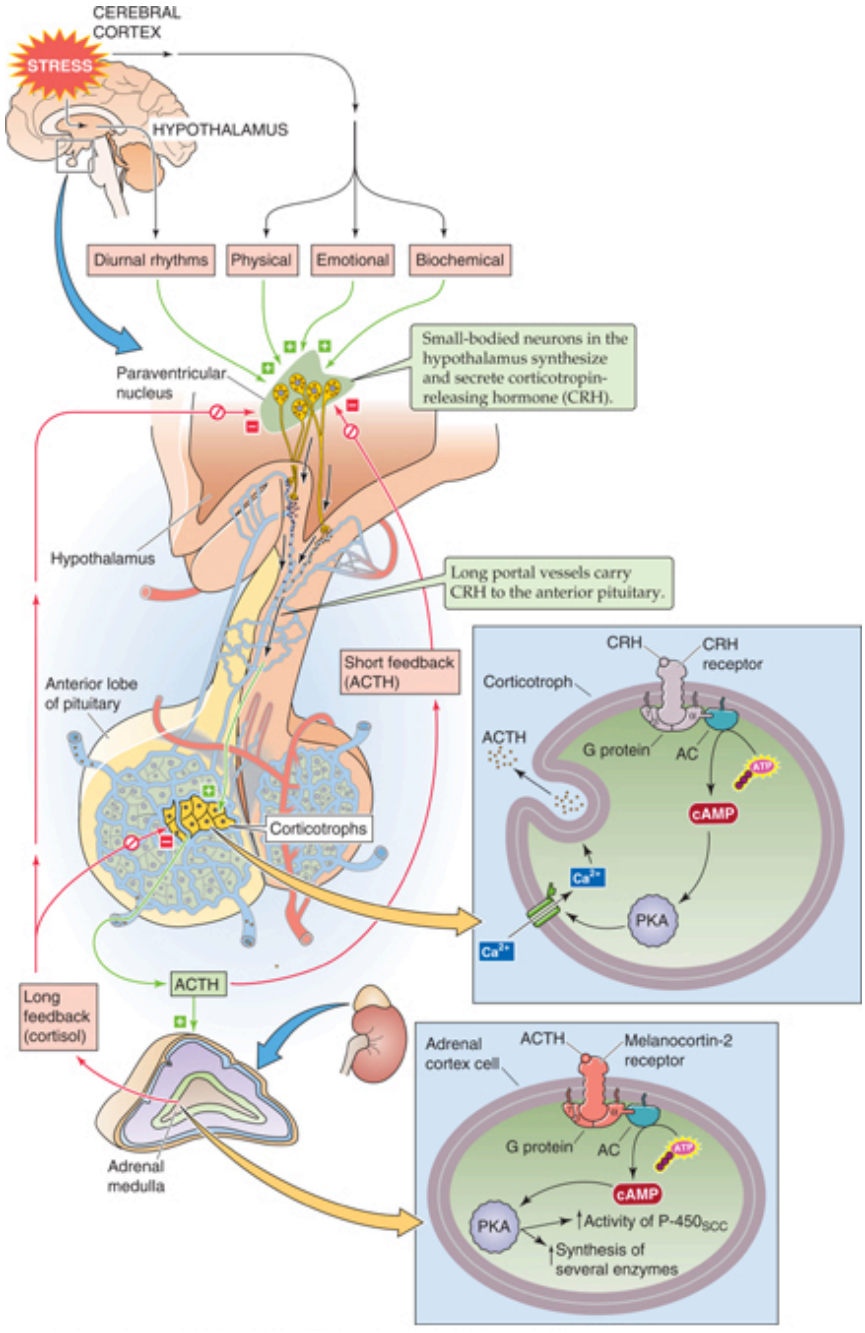

Figure 2. The Hypothalamic-pituitary-adrenal Axis. This figure shows the mechanism which is elicited by stress and accomplished by the interaction of various hormones between the hypothalamus, the pituitary gland and the adrenal cortex of the adrenal gland. (Figure taken from *Medical Physiology* 2nd edition, Boron and Boulpaep, 2009)

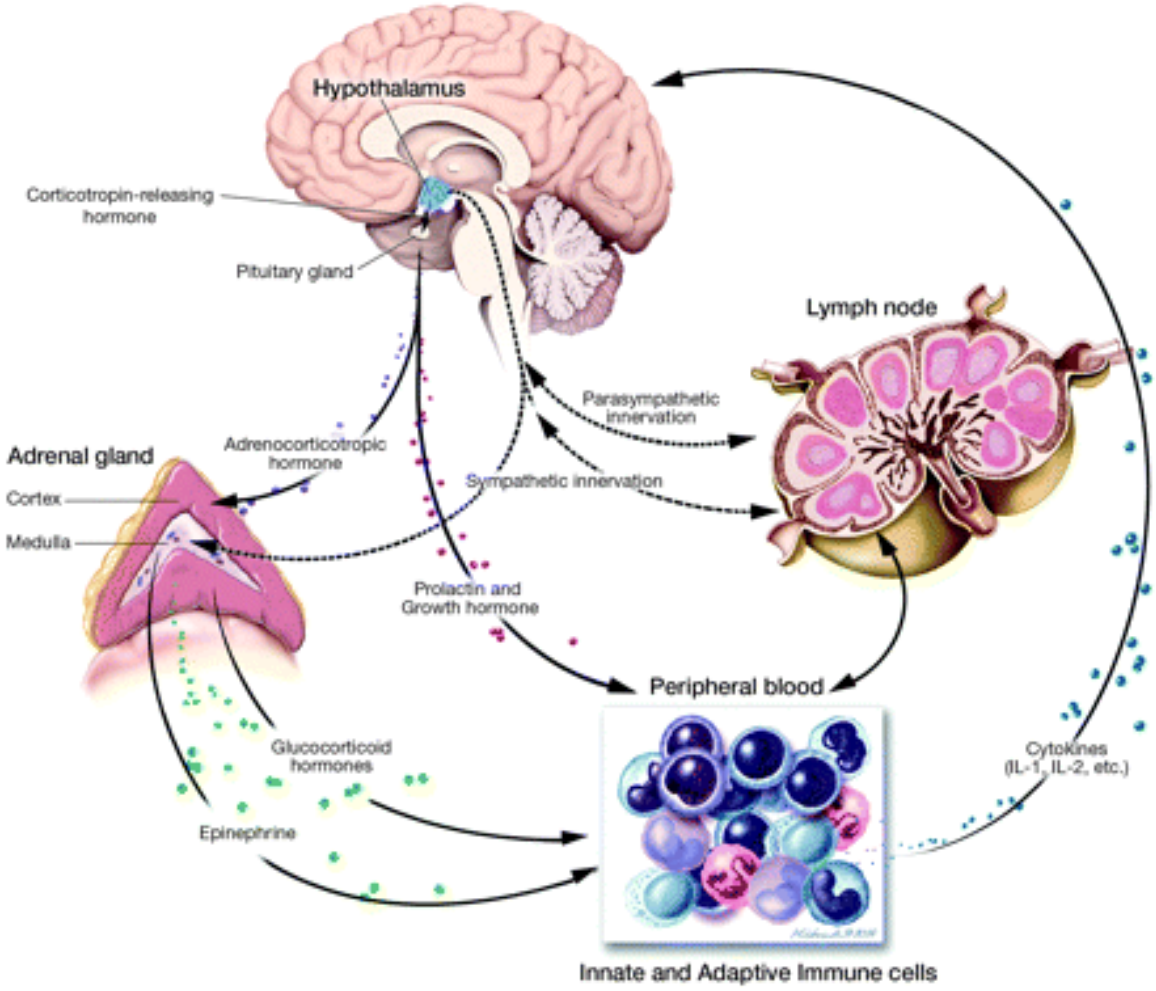

Figure 3. The HPA axis and the SAM system in Perspective. This image shows how the hypothalamus activates the sympathetic response as well as the endocrine response and the interactions of each with the adrenal gland and the immune system. (Figure found at http://www.psychosomaticmedicine.org/content/71/2/117/F5.expansion.html from article: The Rebirth of Neuroscience in Psychosomatic Medicine, Part I: Historical Context, Methods, and Relevant Basic Science. Image previously from: Nature Reviews Immunology, Glaser R and Kiecolt-Glaser JK. Stress-induced immune dysfunction: implications for health. 2005.)

The Sympathetic Nervous System and the Threat Response

The sympathetic nervous system is one of several parts of the autonomic nervous system that continuously works to maintain homeostasis within the body. The autonomic nervous system regulates the body through multiple connections to organs, which vary depending on whether the system is sympathetic, parasympathetic, or enteric. One of the roles of the sympathetic nervous system specifically is to prepare the body for survival in threatening situations. The sympathetic nervous system is made up of preganglionic cells which exit the spinal column via the thoracic lumbar area and synapse on postganglionic cells, which are long and traverse most of the body to make contact with their target organs. Postganglionic cells release norepinephrine (and in certain cases other neurotransmitters such as acetylcholine) which elicit a certain response. With postganglionic innervation adrenergic receptors are activated in the peripheral tissues and specific actions in each organ are manifested such as increased heart rate, cardiac contractility, blood pressure, lung ventilation, sweating, inhibition of insulin secretion, mobilization of blood cells, decreased gastrointestinal activity, pupil dilation, and relaxation of the urinary bladder. (Boron & Boulpaep, 2008). All of these organs and systems are activated by the sympathetic nervous system in response to acute stress, which includes exercise and perceived danger. To increase the chances of survival in situations of immediate danger the sympathetic nervous system mobilizes the body to react to a threatening situation both internally and externally. The physiological responses are manifested with a behavioral response which is commonly referred to as the "fight or flight" reaction, or elaborated to the "freeze, fight, flight, fright or faint"

reaction in the detailed literature of Bracha (2004) and Schmidt (2008). The way in which one reacts is variable and can occur in a hierarchy (freeze, fight, run and then immobilize) or adaptively to the fearful situation. Researchers Barlow and associates describe an adaptive alarm model in which freeze (which he does not differentiate from tonic immobility) may supersede the other reactionary behaviors in specific threatening circumstances (Barlow et al., 2002). It is important to note that as research develops definitions have changed and the freeze response is sometimes referred to as "attentive immobility." Attentive immobility is defined as the initial reaction to the sight of a predator, when an animal sustains their position to go undetected, but maintains motor control and eye movements (Marks, 1987). Our focus here is on tonic immobility, or the inhibition of all motor control as a final defensive response in a stressful predatory situation (Ratner, 1967). The various aspects of this defensive strategy were previously studied in animals and then later in humans.

The initial proposal of a behavioral reaction elicited by the sympathetic nervous system in response to a threat was by Walter Canon in 1915. Canon focused on two of the behavioral reactions, fight or flight, and many basic explanations of the sympathetic nervous system threat response still reflect the emphasis on these two actions. Research is presently turning its focus to tonic inhibition as a defense mechanism, which was originally largely overlooked. Accepted as another possible reaction of the sympathetic nervous system and sometimes referred to as the "freeze" response (though as stated previously, others define this as attentive immobility, different from tonic immobility), tonic immobility is now being researched extensively as a reaction with multiple

implications of its own, from psychological to forensic and cultural. (Freyd, 2008). Research on tonic immobility has most recently centered on the idea of post-traumatic stress disorder and the severity of trauma as indicated by an involuntary immobile response (Amihaesei & Mungiu, 2012. Portugal, 2012 and Bados et al., 2008). Tonic immobility is also being explored in specific traumatic situations such as sexual assault and child abuse. (Fusé et al, 2007 and Heidt et al., 2005). Since this particular behavioral response to danger and stress occurs without a conscious decision to act, here we aim to explore how gender may influence the manifestation of this behavior. Given the very different expressions of these reactions (fighting versus freezing, for example) we are interested in whether females may display a tendency towards tonic immobility as a means to enhance survival.

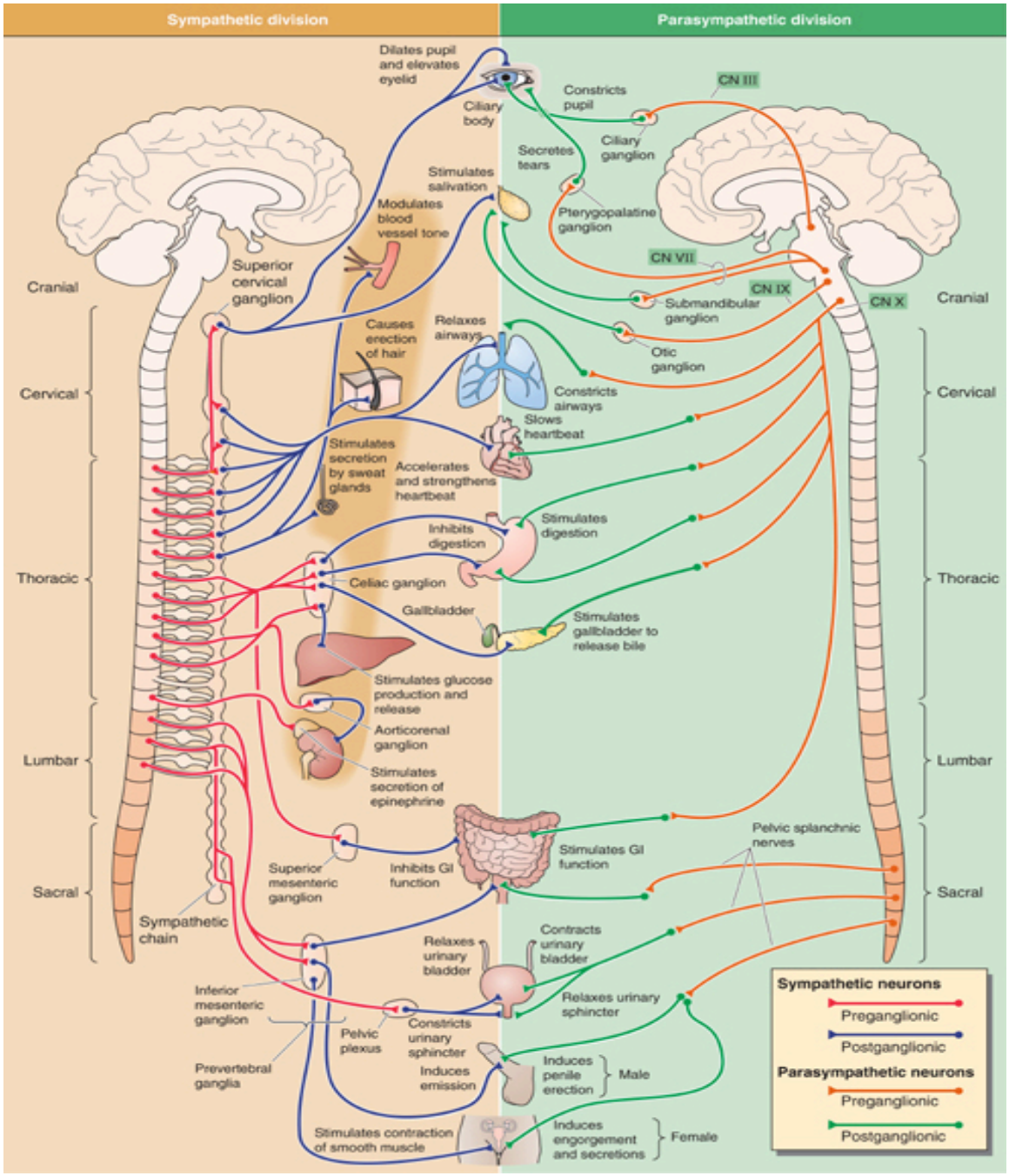

Figure 4. The Sympathetic and Parasympathetic Nervous System Connections. Figure demonstrates connections of the autonomic nervous system. (Figure taken from *Medical Physiology* 2nd edition, Boron & Boulpaep, 2009)

The Sympathetic Nervous Response: Tonic Immobility

Tonic immobility, which is sometimes referred to as the "freeze" response, (Schmidt, 2008) though more frequently now considered its own separate sympathetic response, is the intense inhibition of motor control in response to danger that is perceived as extreme (Volchan, 2011). Tonic immobility is one of several behavioral responses elicited by the sympathetic nervous system. This type of defensive response to stress was initially, and still significantly, researched in animals such as chickens, rats, sharks, snakes, and rabbits. While in certain mammals the data on tonic immobility is relatively new, some of the original literature on tonic immobility came from Athanasius Kircher in the Seventeenth century when he induced chickens to immobility when placed in a certain position, and what he described as hypnotism is now accepted as tonic immobility (see illustrations below.) Much research has already been devoted to inducing and studying tonic immobility in other farm animals and their degree of fear and stress in certain situations. (Gilman et al., 1960). While it has been noted inconsistently that female sharks are affected more profoundly by tonic immobility than their male counterparts, and that differences in tonic response exist in different species, there is little to no evidence thus far on gender differences in the expression of tonic immobility in animals and humans, specifically. The current research on humans and tonic immobility has focused primarily on types of trauma and the occurrence of post-traumatic stress disorder and how previous stressful events which result in tonic immobility will affect the degree of post-traumatic stress (Rocha-Rego et al., 2009). Most of the literature on this topic suggests that tonic immobility is a key reaction when determining the degree of trauma

and sometimes the type of trauma experienced, in both children and adults, with no specific studies looking at gender differences. The literature on this topic will be reviewed and how these studies can be used to add to our hypothesis on variations in tonic response explored as we seek to establish and examine potential gender differences.

Gender Differences in Psychological Physiology

There are genetic and hormonal differences between males and females which define sex. Some of the sexually dimorphic properties of men and women are well defined and important to note. In general men are found to have larger brain volumes (relative to the cerebrum size), more overall white matter, and a bigger anterior corpus callosum (Goldstein et al., 2001). Differences in the amygdala have been found both in synaptic organization (Cooke & Woolley, 2005) and in response to emotional activities (Hamann, 2005). In the hippocampus, neurogenesis was found to be different in male versus female rats (Bowers et al., 2010) and Filipek and associates in 1994 found that human females had a larger hippocampus than males relative to total cerebellar volume. All of these brain dissimilarities are intimately connected to sex differences in androgen hormones, both developmentally and in adult circulation. Initially certain androgen hormones alter the brain development, which is referred to as "masculinization" or "feminization" of the brain (Toren-Allerand, 1984). During adulthood circulating androgens have been shown to account for brain differences such as the volume of a brain nucleus in the medial amygdala (Cooke et al., 1999). To what extent these differences affect behavior and neurochemical processes is the subject of much research. These studies range from pain

and pain inhibition and how females and males differ in their experiences of pain (Mogil, 2012) to stress and coping throughout the span of a lifetime, and how strategies to deal with stress can vary significantly depending on gender and age (Meléndez et al., 2012). Data observed from many studies on gender differences lead us to acknowledge that while many biochemical and physiological similarities are shared in all humans, there are also implications to the differences in males versus females which give further need to explore the underlying processes which define each sex. Our aim here is to simply acknowledge that the differences that have been explored extensively in previous studies makes it clear that gender can be very important in determining behaviors, reactions, and how we integrate knowledge. When differences are found, either in the conclusions of this study or in laboratory and clinical studies, a source of valuable research can then be unearthed by focusing on the underlying factors which may cause these differences, whether it be brain neurochemistry, genetics, or hormonal differences in males and females.

Specific Aims and Objectives

The literature on tonic immobility and the literature on gender differences are important areas for further exploration, and here we aim to find where these two topics intersect. Tonic immobility has been found to have an important link to issues such as PTSD, peritraumatic fear, and interpersonal violence such as sexual assaults. The human manifestation of TI is meaningful in all of these circumstances and help us gain

information relevant to our hypothesis. We will review the literature on these topics and specifically examine:

(1) Tonic immobility in various animals through previous research and preliminary studies on the sympathetic nervous system's threat response, as well as specific situations in which this behavior is exhibited in animals.
(2) Tonic immobility in humans and previous studies that have explored this survival response in various research settings.
(3) The link between tonic immobility and the manifestation of post-traumatic stress disorder, as well as types of trauma in which tonic immobility is found to be a response in humans and the implications of this as a survival response.
(4) Gender differences in physiological psychology, such as behavioral responses in stress situations with a widening scope that explores male and female differences in PTSD, specific trauma and other issues related to stress and coping.

We believe that by identifying the factors that may elicit a tonic inhibitory sympathetic stress response, the influence of these factors, and the addition of data on gender differences, we will be able to draw a novel conclusion and find important areas where future research can be conducted. We hope that new studies can be developed to test the hypothesis developed here and thus contribute significantly to the body of data on gender differences as well as tonic immobility in humans.

Presentation of Published Data

Tonic Immobility in Animals: A Brief History of Relevant Studies

Initial studies on tonic immobility primarily focused on animal models, with specific attention given to farm animals. In a 1950 study by Gilman and associates, researchers focused on inducing tonic immobility, otherwise known as chicken hypnotism or *experimentum mirabile*, which was first noted in the Seventeenth century by Athanasius Kircher (Wadell, 2010). Another study which provides an excellent background in the study of tonic immobility and animals was conducted by Fraser in 1960 and emphasized the beneficial importance of this reflex for survival: "The explanation for its biological significance was that the reduced mobility in the subject would be less likely to provoke an aggressive reaction by an overwhelming power if the latter were present." (Fraser, 1960, p. 330). This is key to our understanding of tonic immobility as a survival mechanism in animals and their research proceeded to detail how many different animals were found to exhibit this behavior in moments of stress. Pavlov, who is most commonly noted for his work with reflexes in dogs, gave considerable attention to this immobilizing phenomenon which he described as a "self-protecting reflex of an inhibitory character." (Pavlov, 1927, p. 70). These studies, which focus on different animals in different situations, from domesticated goats and dogs to wild bats and possums, are notable here for their confidence that the comparative psychological and behavioral information provided by these animals can translate to humans and serve as a practical background for the stress reactions we display. An animal that is closely considered in the study by Fraser is the goat. An important idea which was illuminated in this study is one of

temperament and stress, in which Fraser found that though tonic immobility is displayed in almost all the goat subjects when presented with a stressful situation such as forcible restraint, the amount of stress to elicit this response and the degree of immobilization, i.e. the amount of time the animal spent inhibited, varied widely depending on the individual temperament of the goat. These findings lead us to the conclusion that while this response to stress is common and legitimate, it is also highly variable depending on the subject. While this study did focus on female goats in the context of husbandry, it would be unscientific to make any gender conclusions based on this alone. For our purposes here it is simply important to note both the prevalence of this response in animal models and the fact that it varies considerably depending on temperament, both conclusions we can use to move forward with our discussion on the sympathetic nervous system and the various responses humans have to stress.

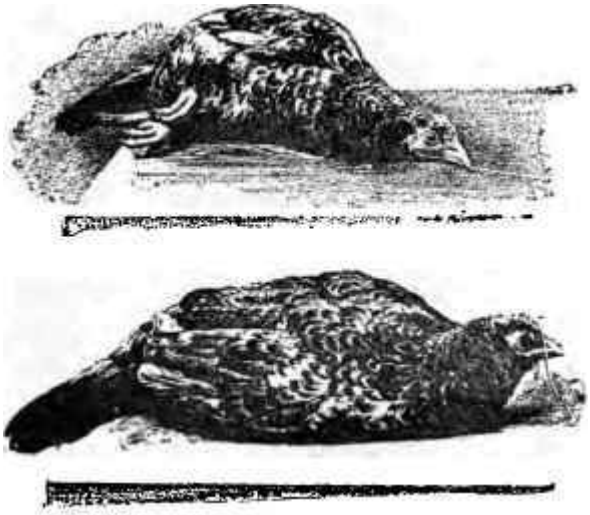

Figure 5. Tonic Immobility in Chickens. This figure demonstrates the original observation by Athanasius Kircher on the hypnotism of chickens, which was later referred to as tonic immobility. (Figure taken from http://chestofbooks.com/health/hypnosis/Hypnotic-Suggestion/Animal-Hypnotism-Continued.html#.URbXiBgjw7A, 2013)

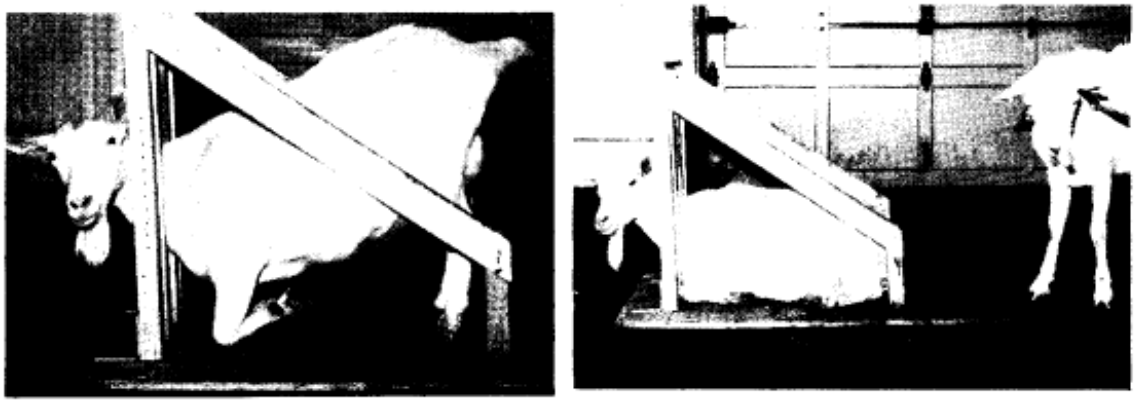

Figure 6. Tonic Immobility in Goats. This figure demonstrates tonic immobility occurring in a female goat. (Figure taken from *Spontaneously Occurring Forms of "Tonic Immobility" in Farm Animals*, Fraser, 1960)

Tonic Immobility in Humans

From the previous studies we have detailed it was apparent that the next direction of study would be discovering the expression and degree of tonic immobility in humans. Despite the fact that several animal studies were done in previous years with parallels to human behavior, it is only fairly recently that researchers began to focus on tonic immobility in humans. Some of first researchers to extend the idea of tonic immobility to humans were Susan Suarez and Gordon Gallup, who up until their 1979 article had explored tonic immobility extensively in animals such as chickens and ducks. Using their previously obtained data as a guide, Suarez and Gallup made the leap to say that tonic immobility did occur in humans, and in the modern world the most likely situation where TI would manifest is rape. To test their hypothesis Suarez and Gallup interviewed rape victims and found what they considered significant reports of TI in 40% of victims. While this study opened the door for more research in the area of TI and humans, it was largely ignored. Not until many years later did scientists see the value in the findings of Suarez and Gallup and begin to take human TI into consideration in their studies of trauma, rape, and general interpersonal violence. In 2000 a scale for measuring tonic immobility in humans (the TIS) was created by Forsyth and associates. An exploratory and confirmatory factor analysis was conducted in 2007 on the TIS using female sexual assault victims, a study which we will explore later in our review. Now the TIS is used in most research scenarios where TI is being evaluated. Once TI was established as existing clinically in humans, a key study done was conducted in 2011 by researchers in Brazil which sought to substantiate these findings physically in the laboratory. The aim of this

study was to demonstrate that TI existed in humans, with tonic immobility being described as " …profound motor inhibition… elicited under inescapable threat in many species" (Volchan et al., 2011, p. 13). This study differentiates tonic immobility from the freeze response in the series of defensive strategies elicited by the sympathetic nervous threat response. Dr. Volchan and his associates define the freeze response as "attentive immobility" and described this response as a way for threatened animals to go undetected when predators are perceived without profound inhibition of movement, thus it can be immediately followed by the fight or flight response. Tonic immobility is defined as a fourth reaction, and as detailed above, the main feature of this response is the overpowering inhibition of all motor function as a result of extreme stress. The idea presented by Dr. Volchan and associates is that when an animal is caught by a predator, it will exhibit this behavior as a last survival response with the hope that the predator will discontinue the aggressive attack with implications in human behavior and interpersonal violence being a connection to these ideas on a sociological level, as previously presented by Suarez and Gallup. Dr. Volchan and associates do explore the expression of tonic immobility in human cases of violence, specifically with females, and this will be investigated later in our discussion on tonic immobility, stress, and gender. The methods of the study conducted by Dr. Volchan involved thirty-three participants, eighteen of which were diagnosed with PTSD. The participants in this study detailed what they considered to be the most traumatic experience of their lives, giving sensory and reaction information as well as any other significant details that would describe the event. The perceived elements of the trauma were written down and then read and recorded in a

neutral male voice. The recording created by each individual's experience was then played back to them as they were measured for levels of tonic immobility and stress, using body sway as a measure of mobility and an electrocardiogram to detect heart rate. Participants in this study were also given a questionnaire on feelings of immobility during their traumatic experience. The researchers used these measures to compare body sway in a neutral situation to sway during the playback of their recorded trauma and found significant evidence of tonic immobility in their participants during the playback period. Researchers also compared the degree of perceived TI from the questionnaire to measures of body sway during playback and found that increased reports of TI were associated with decreased body sway. This study also evaluated participants for PTSD and found that subjects with the disorder experienced higher reports of inhibition during the playback period, similar to those reported during the actual trauma. These findings suggest a re-experiencing of symptoms that is significant to the expression and diagnosis of PTSD. The raw data showing their subject's amount of displacement and heart rate is presented in the figure below. This study was one of the first to simulate tonic immobility in the laboratory and record physical information on the human expression of tonic immobility. This study helped to clarify the biological aspects of tonic immobility by providing information such as variations in heart rate and degree of body immobilization. This is important because it acknowledges that the involuntary manifestation of this stress response can have different consequences depending on the situation in which it presents itself and provides further evidence for this response in humans. The study by Volchan and associates did not make any mention of finding

gender differences in TI based on their data. This is unfortunate missed opportunity as the data obtained included both males and females and differentiation between genders could have here been explored. In many of the experiments we will discuss presently only females were used as participants, most likely because of the higher rates of interpersonal violence, like sexual assault and domestic abuse, reported by women.

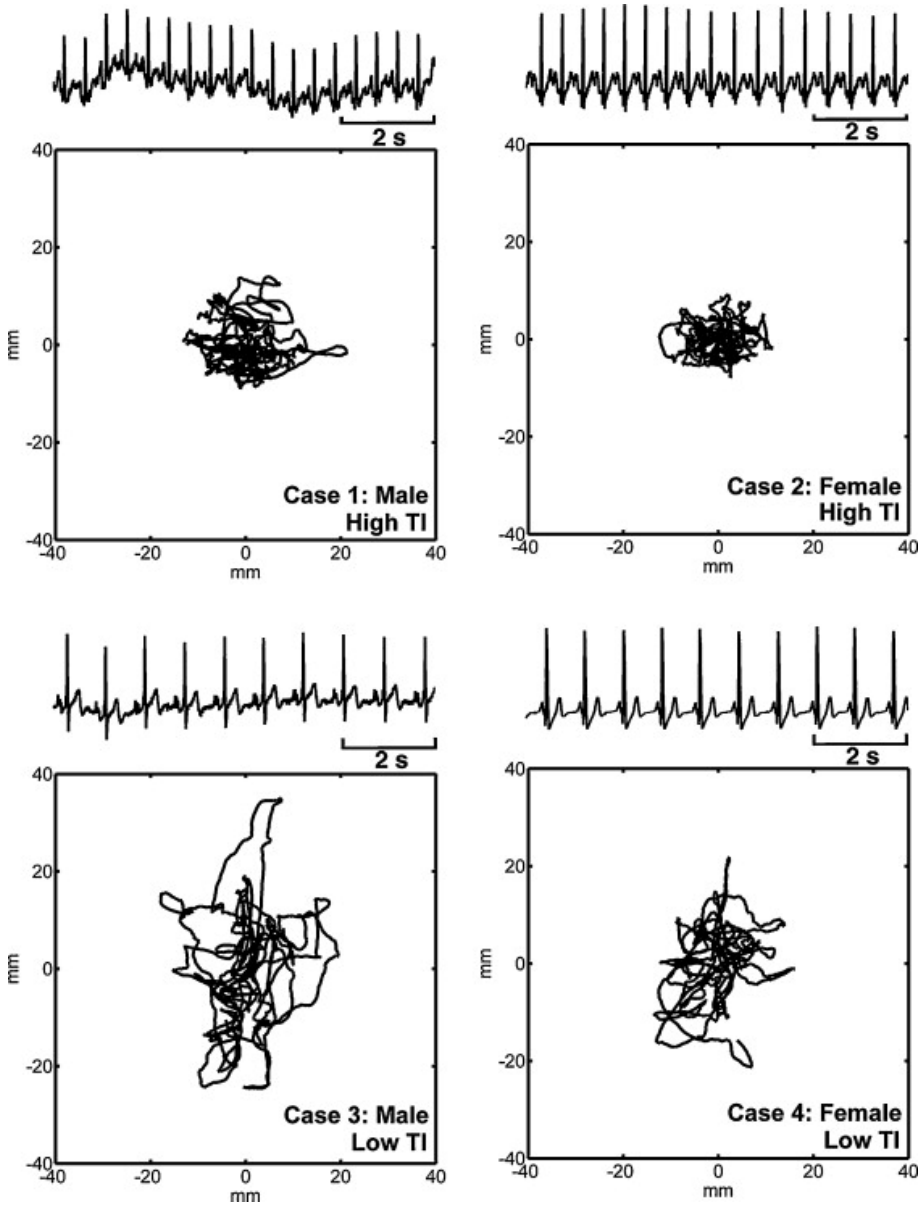

Figure 7. Measures of Tonic Immobility in the Laboratory. This figure exhibits the raw data on body sway and heart rate in participants in the Volchan study and displays significant tonic immobility in participants while re-experiencing their trauma under experimental conditions. Body sway was measured by recording the millimeters of displacement from the participants center of pressure for sixty seconds after their recording was played. (Figure taken from Volchan et al. 2011)

Implications of Tonic Immobility and Post-traumatic Stress Disorder

Studies on tonic immobility now are focusing on perceived trauma by humans. Since tonic immobility is a defense strategy employed in stressful and life-threatening situations, the link between the trauma experienced and the extent of tonic immobility is explored in several laboratories. As we have already seen, researchers started making connections between trauma and TI as early as 1979 when Suarez and Gallup described rape as a primary elicitor of TI in humans. One of the ways in which we evaluate trauma in humans is by the presence of disorders such as PTSD. In this way peritraumtic fear and TI would seem to have associations with the expression of PTSD, an idea that we saw Volchan explore. Before Volchan's experiment, Dr. Bados and associates conducted an important study on TI and PTSD in 2008. In this study Bados and his colleagues compared the type of trauma experienced to the level of tonic immobility perceived by participants. The level of trauma experienced was determined by using three measurements on the population, one of which was the *Traumatic Events Questionnaire* developed by Lauterbach and Vrana in their 1994 study *Prevalence of traumatic events and post-traumatic psychological symptoms in a nonclinical sample of college students.* Using the TEQ, researchers were able to deduce that most of the participants tested had some form of trauma in their past. They then compared the traumatic event experienced to the degree of tonic immobility reported by their participants using the Tonic Immobility Scale (TIS) of Forsyth, Marx, Fusé, Heidt, and Gallup (2000). The TIS is a self-report that measures the presence and degree of indicators of tonic immobility, such as paralysis, dissociation, and trembling that the participant can recall experiencing

during a fearful traumatic event (Davis et al., 2006 and Fusé et al., 2007). This was then further compared to *The Purdue Posttraumatic Stress Disorder Scale-Revised* (PPTSD-R; Lauterbach & Vrana, 1996). The PPTSD-R determines the amount of post-traumatic stress symptoms experienced in the previous month so that the level of PTSD indicators could be assessed. The findings of this study did not find significant differences in TI depending on the types of trauma experienced, though it was noted that the mean tonic immobility score, obtained from measure such as the TIS, was significantly higher in the group of participants who reported experiencing sexual, physical or psychological abuse directly than in the group of participants who reported hearing news about the serious injury or death of someone close to them.

Table 1. Data for PTSD, Tonic Immobility, and Trauma. These are the means and standard deviations for the data obtained in the study *Traumatic Events and Tonic Immobility* (Bados, et al. 2008) which show the increased reports of tonic immobility with PTSD symptoms in participants with trauma.

	Trauma $n = 70$[a]		No trauma $n = 25$[b]		Statistical test[c]	p	Effect size (r)
	M	*SD*	*M*	*SD*			
PPTSD-R	30.10	12.78	21.08	6.47	$z = 3.585$	.0003	.37
Physical immobility	17.09	7.27	10.60	7.08	$t = 3.855$	.0002	.37

Note. PPTSD-R = Purdue Posttraumatic Stress Disorder Scale-Revised.
[a] $n = 68$ in the case of the PPTSD-R. [b]Of the 30 people who did not report traumas, 5 did not complete the items about posttraumatic stress and physical immobility. [c]Mann-Whitney's z for the PPTSD-R (the assumption of normality was not met) and t-test for physical immobility.

Table 2. Data in Comparisons of Tonic Immobility and Perceived Trauma. This table shows the mean scores of the TIS compared the type of trauma on the amount of immobility in participants. Note the difference in means between the "News about mutilation, serious injury or death of a loved one" as compared to the "Physical/psychological or sexual abuse" trauma category (Bados, et al. 2008).

Types of Trauma											
Serious travel accident $n = 10$		Assault or physical aggression $n = 9$		Physical/ psychological or sexual abuse $n = 13$		News about mutilation, serious injury or death of loved one $n = 20$		Other traumas[a] $n = 18$		p	Effect size (r)
M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*		
19.30	8.37	16.89	8.40	20.00	6.47	14.40	5.60	16.83	7.85	.217	.29

Note. [a] This category included witnessing traumatic events ($n = 7$), serious danger of losing one's life ($n = 3$), death of loved ones ($n = 3$), serious disease of self or loved one ($n = 2$), and trauma that cannot be disclosed ($n = 3$).

The study is significant as it is one of the preliminary investigations into types of trauma affecting degree of tonic immobility in humans. Though there were no significant differences found in the type of trauma and TI, one category was observed to have significantly less TI reported as compared to the category of trauma of high TI (physical/psychological or sexual abuse) which suggests that TI is most likely more common in directly experienced trauma, and most especially in sexual assaults. This study helps to support previous assertions that tonic immobility is a response expressed in major trauma such as sexual assaults. The findings of Dr. Bados and associates usher us into other studies that focus on post-traumatic stress disorder. Post-traumatic stress disorder is an anxiety condition that can occur after a stressful event in which the person's life or personal safety is threatened and they feel fear, helplessness and extreme psychological distress. (DSM-IV-TR)(1). In PTSD, various symptoms present themselves

after the traumatic event such as sleeplessness, anxiety, and an increased stress response that can be associated with lower base cortisol levels and increased epinephrine (Amihaesei, Mungiu, 2012). Increased tonic immobility during the event (Bados, et al. 2008) is a predictor of the severity of later PTSD symptomology (Rocha-Rego et al. 2009). Previously, Michelle Bovin and associates came to similar conclusions in their study *Tonic Immobility Mediates the Influence of Peritraumatic Fear and Perceived Inescapability on Posttraumatic Stress Symptom Severity Among Sexual Assault Survivors* (2008). In the study conducted by Dr. Bovin, significant data was found on tonic immobility and its relation to various PTSD symptomology, peritraumatic fear, and perceived inescapability. This study was conducted with only female sexual assault victims and thus relates very precisely to our topic here, though we are unable to compare data and make conclusions about gender differences specifically. The results of this study are important because they signify the importance that tonic immobility plays in traumatic events and how they are perceived. The study shows that the degree of tonic immobility in the victims of sexual assault survivors mediated the degree of PTSD symptomology. Dr. Portugal and associates conducted another study that substantiates the findings just detailed but includes male and female participants in Brazil: *Peritraumatic tonic immobility is associated with posttraumatic stress symptoms in undergraduate Brazilian students* (2012). Similar conclusions were drawn about the severity of PTSD and the amount of tonic immobility experienced in a population of Brazilian undergraduate students in a non-clinical setting. Increased levels of tonic immobility positively correlated with severity of PTSD symptoms and difficulty of later

PTSD treatments. The connection between TI and PTSD prognosis was also explored by Lima in 2010, who found that the best predictor of a poor response to PTSD therapeutic treatment was the presence of peritraumatic TI. Lima also stated in this study that TI was the best predictor of poor treatment response compared to dissociation and peritraumatic panic. These findings were substantiated with pharmacological treatment of PTSD being tested in a 2008 study by Fiszman and associates. While this study states that TI was a phenomenon found only in female sexual assault victims previously, researchers used victims of urban violence with PTSD of both genders. Fiszman found that of the 43% of male and female participants who experienced peritraumatic TI there was significant predictive value in a poor response to pharmacological treatment of PTSD. Another important impact of his study was determining the presence of peritraumatic TI in men. The study of TI in humans has taken a strongly directed path towards its manifestation and impact in female sexual assault cases, perhaps because of the original work by Suarez and Gallup. The study by Fiszman, and the other studies we have seen using male participants, help to illuminate TI as a phenomenon of both genders.

Stress and Gender Differences

As discussed previously, research into gender differences has been extensive in recent years, with the focus of investigation spanning from differences in cardiovascular disease and cancer to smoking and alcoholism. Both physiological and psychological differences in males and females have been illuminated in some cases, while others have been rejected in a variety of medical circumstances. Since we have previously determined that

tonic immobility is seen most commonly in circumstances of sexual abuse and other situations of extreme interpersonal violence, it would now be most pertinent to look at gender differences in stress and trauma, how it is perceived, expressed, and experienced by different genders. To do this we can start at the very basics of the stress response, the hypothalamic-pituitary-adrenal axis discussed earlier. This is a response to a longer duration of stress and is indirectly connected to the SAM system, which is the hypothalamic activation of the autonomic stress response detailed previously. Both of these systems interact to contribute to the physiological responses to stress. (Gerra et al., 2001). The HPA-axis has been linked to depression, sleep disorders, reproductive issues, and anxiety disorders. This system is a pertinent start to our discussion on gender as it drives the general stress system, and along with the hippocampus and the amygdala, it is anatomically dimorphic depending on sex in animals and humans (Kudielka, 2005). It has also been found that there are sex differentiations in the hormonal regulation within the HPA axis (Patchev, 1998 and Kudielka. 2005).

Kudielka and Kirschbaum gave a significant review on gender differences and stress in their 2005 article: *Sex differences in HPA axis responses to stress: a review*, which helped to bring together many different studies that related to stress and gender. Kudielka outlines how animal studies show glucocorticoid levels being higher in females than in males, as determined in several rat studies (Haleem et al., 1988). Other studies show that the role of gender in the stress response is much more variable in humans. Kudielka gives an excellent outline on the different factors that sex differentiation can influence, such as endocrine variances due to gonadal steroids as well as dissimilarities in

corticoid steroids involved directly in stress and brain function. Overall it was determined, based on her research in a previous study on stress and gender, that generally men have higher cortisol levels than women. Her graphs show that free salivary cortisol levels and ACTH levels were higher in males than females in a psychologically stressful situation, but also that plasma cortisol levels were slightly greater in women (See figure 9). Her conclusion stated that when all measures were controlled for, she believed men responded to stress with higher levels of cortisol than women. While at first these findings may seem divergent from our hypothesis, which thus far has presupposed that females could experience stress more acutely, it is important to recognize that cortisol and the functioning of the HPA axis, while connected, is not directly involved in the sympathetic threat response. The SAM is immediate and elicited by a more intense trauma than the psychological stress that is explored in this study. Since the hypothalamus controls both the overall stress response of the HPA axis and the SAM system which we are interested in, it is important to discover ways in which these two systems relate, as gender has been explored much more copiously and easily in the HPA axis system. A study which helps bridge the gap between the long-term and acute stress responses was conducted in 2011 by Dr. DeSantis and associates on gender differences, early trauma, and HPA axis function. This study focused on the modifying effect of gender in early life trauma, which is presumably affected by the SAM system, and the formation of the HPA axis and its control of current perceived stress. Participants were healthy males and females of varying ages and backgrounds who were filtered so that contributors were screened and excluded for having mental disorders such as major

depression, bipolar disorder, psychotic disorders, and eating disorders. Participants were also given the Early Trauma Index, or ETI, in the beginning of the study to assess levels of early life trauma. The method of this study was to first measure baseline corticotropin levels, then administer corticotropin-releasing hormone (CRH) to participants over a two-day period. At the end of the period participants were asked to complete a Trier Social Stress Test (TSST). The TSST is used to cause stress, which will induce a physiological response that was then measured. Corticotropin levels were recorded at baseline in each participant, again during the CRH provocation period, and then finally plasma cortisol levels were recorded at various points throughout the stress test. The results of this study were trifold, as they looked at how baseline corticotropin measurements compared to gender, how cortisol and corticotropin response to CRH administration compared to gender, and at how the stress response to the TSST was affected by gender. For the first comparison, DeSantis and associates found that women had significantly higher levels of baseline corticotropin than men, with high positive correlations between baseline corticotropin levels and the participant's trauma effects factor score as well as their severe trauma factor score (see figure 9). This led to the conclusion that gender alters the influence of trauma on baseline corticotropin levels (DeSantis, 2011). These findings relate to our discussion by demonstrating that despite previous studies that show men have higher levels of salivary cortisol during stress, women may show higher physiological stress responses depending on previous experiences. The fact that the severity of early life trauma, gender, and baseline corticotropin levels were positively correlated in women and negatively so in men definitely points us in a direction where

gender and sympathetic nervous threat response would appear to be implicated. We will further extrapolate later on what this means for our hypothesis, but a rudimentary interpretation would seem to elucidate the idea that an intense early sympathetic response to trauma may have altered the hypothalamus in future stress situations, with gender being a significant factor in the degree of alteration and later responses.

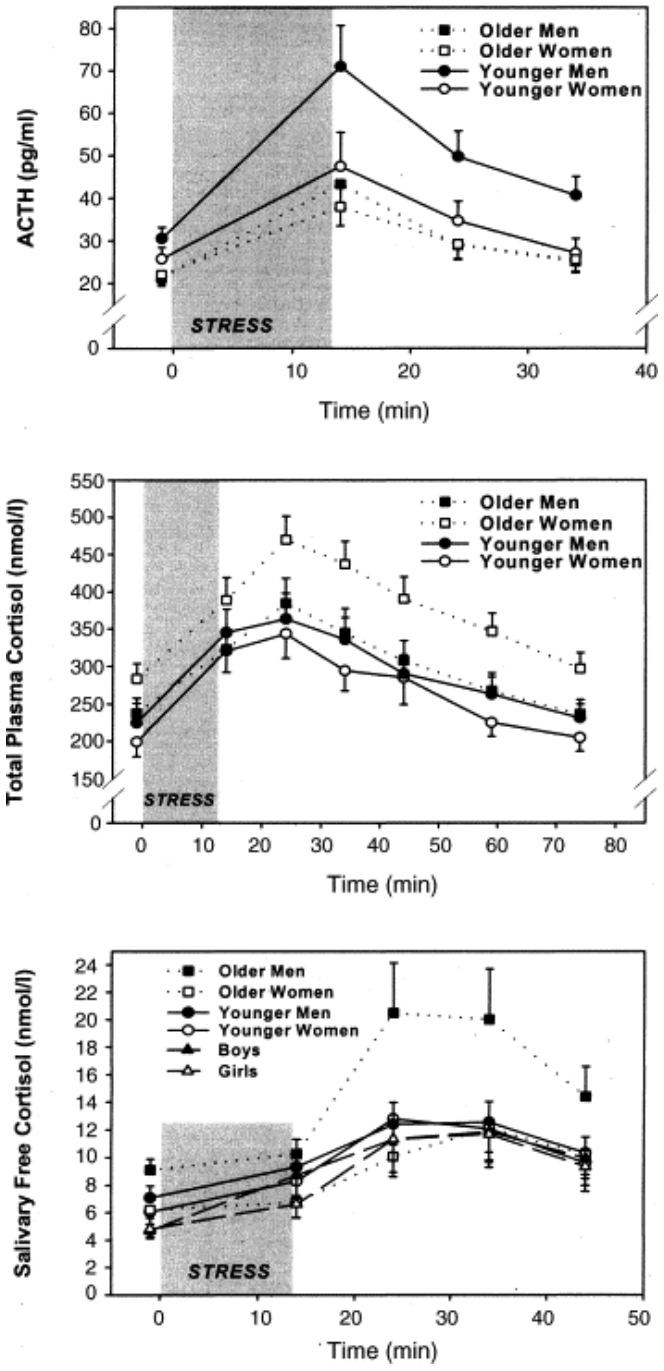

Figure 8. Differences in Mean ACTH and Cortisol in Men and Women of Various Ages. This figure shows the amount of ACTH, plasma cortisol and salivary free cortisol in men and women of different ages before and after a stress test. The shaded areas signify the time period when the Triers Social Stress Test was administered. (Figure from Kudielka, 2005).

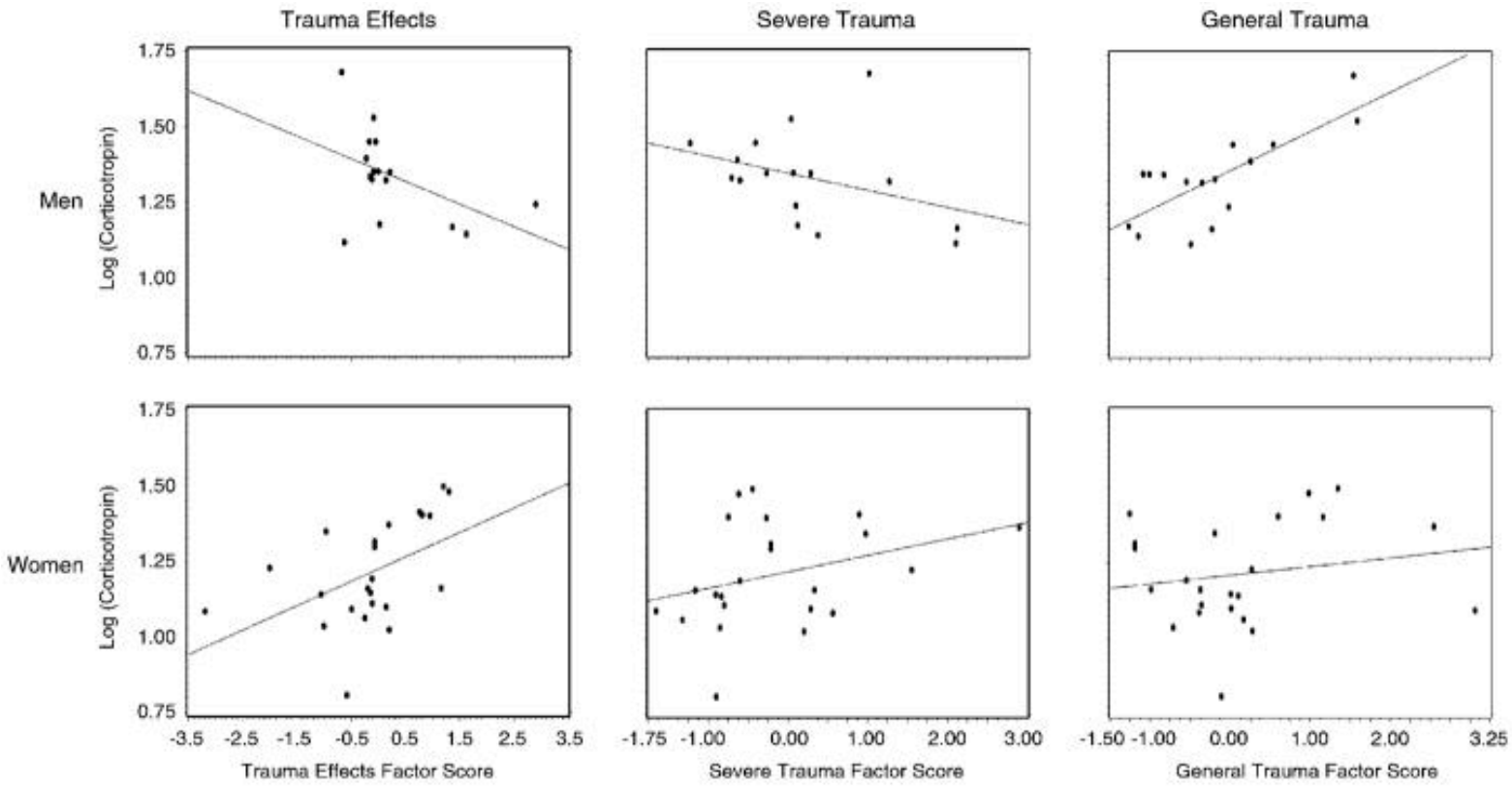

Figure 9. Baseline Corticotropin in Males and Females and its Relationship to Scores on the Trauma Scale. These graphs show that trauma effects and the severity of trauma were highly positively associated with baseline corticotropin in women but negatively associated with baseline corticotropin in men. (Data and explanation obtained in the study by DeSantis et al., 2011).

Stress, Trauma, and Gender

So far we have explored the various aspects of physiological stress, such as different types of stress and the long term effects of stress such as PTSD, all in the context of gender. In reviewing the published data on our topic, there is a wealth of research in specified cases of trauma and TI, such as sexual assualt and childhood sexual abuse. The data obtained in these particular studies are important to review here, as they involve several of the issues we have already discussed and provide further insight into our topic.

An important study which explored tonic immobility included eighty female participants to investigate the expression of TI in childhood sexual abuse and evaulate the concept of a specific tonic reaction in humans known as "rape-induced paralysis." (Burgess & Holmstrom, 1976). This study, *Tonic immobility and childhood sexual abuse: a preliminary report evaluating the sequela of rape-indced paralysis*, conducted by Jennifer Heidt and associates in 2005, looked at the prevalance of tonic immobility in women who suffered from childhood sexual abuse. Since this study included only female participants, we have no basis for gender comparisons, but this choice provides interesting insight into who we consider typical victims of sexual assault and the fact that women are victims of interpersonal violence in greater numbers than males, and what this might suggest for our hypothesis. Heidt and her colleagues were working to determine the frequency of tonic immobility in sexual assault victims based on clinical findings which would parallel animal study findings on sympathetic nervous responses. It is suggested that the expereicne of rape is very similar to the predation circumstances in which tonic immobility in animals arise, such as extreme fear, restraint, and immediate

danger. These parameters, as well as the observations of most clinicians that victims of rape and sexual abuse often described the physiological effects of tonic immobility similarly to lab evidence obtained in TI studies, led Heidt and her associates to survey the degree of occurance of this reaction in childhood sexual abuse, as well as its psychological correlations, such as PTSD and anxiety. (Heidt et al., 2005). In this study, the hypothesis consisted of two dimensions: that a high-degree of TI would be found in childhood sexual assault cases and that this would correlate to a greater extent of psychological symptoms. They also hypothesized that the greater the age difference in the victim and the perpetrator of the sexual assault, the greater the degree of TI would be found in the victim, due to increased feelings of fear and perceived restraint. The methods of this study consisted of recruiting females by using the *Posttraumatic Stress Diagnostic Scale* (Foa, Cashman, Jaycox, & Perry, 1997). This test, abbreviated to PDS, is used to evaluate level of past trauma and its concurrent psychological impact. This test was used to recruit eighty participants, approximately half of which were from a college population and the other half from a psychiatric care facility to control for clinical and non-clinical presentations of symptoms. The eighty participants were then tested for psychological symptomology with several measures, such as the *Beck Depression Inventory* and *The State-Trait Anxiety Inventory* as well the *Tonic Immoblity Scale – Child Abuse Form* (TIS-C) to obtain details on past trauma, current symptomology, and important details for consistency and comparison. The findings of this study did yield significant results, and in regard to abuse characteristics and extent of tonic immobility, these two factors were very positively correlated with age of attacker and fear scale

scores, more so in the cases of rape as opposed to non-penetrating sexual abuse. This study also found positive correlations between extent of tonic immobility experienced by victims and their current psychological symptoms, such as PTSD, depression and anxiety. The data are shown in the table below. This study supports previous findings on the prevalance of tonic immobility in sexual assault and the manifestation of TI as an indicator of later symptology in disorders such as PTSD. Heidt and associates also shed some light on our topic by looking at childhood sexual assault as another form of relevant human trauma in which TI may manifest. This study helps clarify both how tonic immobility is induced in humans and ways that the expression of TI in events can help us to understand psychological ramifications of traumatic events.

Table 3. Correlations Between Reported TI and Psychological Symptomology. This table shows significant data from the Heidt study and shows how TI relates to psychological symptoms such as depression and PTSD. (Table found in *Tonic immobility and childhood sexual abuse: a preliminary report evaluating the sequela of rape-indced paralysis*, 2005)

	Tonic Immobility Scale	
	TI Factor	Fear Factor
BDI	.47**	.33**
STAI-T	.41**	.37**
PDS	.49**	.38**
PDEQ	.37**	.43**

Note. TIS-C; Tonic Immobility Scale—Child Form; BDI = Beck Depression Inventory; STAI-T = Spielberger Trait Anxiety Inventory (Form-Y); PDS = Posttraumatic Diagnostic Scale; PDEQ = Peritraumatic Stress Experiences Questionnaire. **$p < .01$.

A study which closely relates to the preceding one directly explored the factor structure of the TI scale used in the previous study, a scale developed by Forsyth and associates in 2000, as it relates to specificity of experiences in female sexual assault victims. The *Tonic Immobility Scale* has been used more and more frequently now that TI is considered legitimate and predictive in traumatic situations. As we just saw, Heidt used a version of this scale to assess her sexual assault victims, and the study we are reviewing now aimed to analyze the factors of this scale in the context of female sexual assault survivors specifically. This study, conducted by Tiffany Fusé and associates, titled: *Factor structure of the Tonic Immobility Scale in female sexual assault survivors: An exploratory and Confirmatory Factor Analysis* (2007) primarily worked to analyze the TIS as a psychological assessment and the accuracy of valuation in purposely evaluating female sexual assault victims. This study involved two parts. The first part used the statistical method of Exploratory Factor Analysis to look at scores on the TIS of sexual assault survivors. The Exploratory Factor Analysis is used when there is a large set of variables in which one seeks to find underlying relationships because there is an assumption that each measure in an assessment, such as the TIS, relate and contain information shared in the other measures of the test (Tinsley & Brown, 2000). The Exploratory Factor Analysis was run on the TIS results of a group of eighty-eight female sexual assault survivors. The second part of Fusé's study involved running a Confirmatory Factor Analysis (CFA) on similarly obtained data, which is a statistical method that tests for consistency in the nature of factors based on the inherent qualities of the factors (Kline, 2010). This test was run on test scores acquired from a second group

of one hundred and ninety one female sexual assault survivors to test for internal consistency within the TIS test. Fusé and associates used central information from animal studies to focus on two parameters that induce tonic immobility: extreme fear and physical restraint. Previous data from numerous studies confirms that a tonic response is more likely to be induced with the presence of these two factors, which have already been described as inherent to a sexual assault by investigators such as Heidt. In the first study Fusé and associates administered the TIS to female victims of sexual assault and used this data to find correlations between the factors in tonic immobility such as temperature, paralysis and numbness. It was found that the TI factor explained 43.76% of variance, while fear explained 23.5% and added, 67.26% of the variance was explained by these two factors together, which Fusé believed to be the main components of a sexual assault. (Fusé et al., 2007). The results of this first study can be found in tables below.

Table 4. Data From: *Factor structure of the Tonic Immobility Scale in female sexual assault survivors: An exploratory and Confirmatory Factor Analysis.* This figure shows Means, Standard Deviations and Intercorrelations of the TIS and show the results of the initial EFA. (Table from Fusé et al., 2007).

Item	1	2	3	4	6	7	8	9	10	11
(1) Froze/paralyzed	2.11	.80	−.05	.76	.33	.71	.03	.54	.80	.08
(2) Unable to move		2.16	−.04	.78	.32	.59	.06	.47	.75	.16
(3) Trembling/shaking			2.51	−.13	−.26	.03	.64	−.01	−.10	.55
(4) Unable to vocalize				2.19	.31	.57	.12	.37	.75	.09
(6) Numb/no pain					2.16	.41	−.19	.20	.35	−.06
(7) Felt cold						1.91	.00	.40	.63	.08
(8) Fear/panic							2.47	−.01	.08	.74
(9) Feared for life								1.63	.45	.02
(10) Detached from self									2.11	.05
(11) Detached from environment										2.46
Mean	1.72	1.81	3.30	1.76	1.74	1.36	3.26	.84	2.00	3.24

Note: $N = 88$. Data are based on initial Exploratory Factor Analysis. Standard deviations are presented along the main diagonal.

Table 5. Further Data From: *Factor structure of the Tonic Immobility Scale in female sexual assault survivors: An exploratory and Confirmatory Factor Analysis*. This table shows the two-factor EFA result for study one in a rotated pattern matrix. One can see the amounts of factor overlap on the right. (Table from Fusé et al., 2007).

TIS-A items	Factor 1	Factor 2
(1) Rate the degree to which you froze or felt paralyzed during your most recent experience	.927	.018
(2) Rate the degree to which you were unable to move even though not restrained	.871	.067
(3) Rate the degree to which your body was trembling/shaking during the event	−.094	.709
(4) Rate the degree to which you were unable to call out or scream during the event	.829	.037
(6) Rate the degree to which you felt numb or no pain during the event	.409	−.21
(7) Rate the degree to which you felt cold during the event	.730	.017
(8) Rate the extent to which you felt feelings of fear/panic during the event	.040	.924
(9) Rate the extent to which you feared for your life or felt as though you were going to die	.523	−.002
(10) Rate the extent to which you felt detached from yourself during the event	.867	.009
(11) Rate the extent to which you felt detached from what was going on around you during the event	.085	.783

Note: A varimax rotation was implemented. TIS, Tonic Immobility Scale (Forsyth et al., 2000).

This first study was important for validating the consistency of the TIS with female sexual assault victims, as well as identifying key factors of TI in the sexual assault situation.

This first study led to the second study of Fusé's investigation. The second study involved an analysis by Fusé and associates which strove to validate the two factors found previously, TI and fear, to find if they could be confirmed as integral to sexual assault by using a CFA on the obtained data. The goal of this analysis was to provide the best analytical model for understanding and studying the tonic response in female sexual assault victims particularly. To obtain information on the generalizability of the TIS scale factors, Fusé and associates performed the same procedure as in their initial study, but with a different set of female participants and a much larger population. They then proceeded to use a confirmatory factor analysis on the data obtained using a maximum

likelihood estimation, or MLE. The same parameters as tested before with the TIS but now with the new population and using the CFA can be seen in the table below.

Table 6. Data from Study Two in *Factor structure of the Tonic Immobility Scale in female sexual assault survivors: An exploratory and Confirmatory Factor Analysis.* This table shows the second set of data obtained using a different and greater population of participants run with a confirmatory factor analysis. This can be compared to data from the previous table. (Table from Fusé et al., 2007).

Item	1	2	3	4	6	7	8	9	10	11
(1) Froze/paralyzed	2.14	.82	.03	.60	.34	.41	.25	.44	.54	.11
(2) Unable to move		2.17	.01	.72	.34	.39	.26	.41	.52	.13
(3) Trembling/shaking			2.25	.02	−.02	.15	.41	.13	.08	.37
(4) Unable to vocalize				2.38	.30	.46	.17	.50	.46	.06
(6) Numb/no pain					2.10	.28	.04	.36	.24	.01
(7) Felt cold						2.12	.12	.40	.40	.13
(8) Fear/panic							2.09	.25	.16	.40
(9) Feared for life								1.69	.27	.07
(10) Detached from self									2.16	.22
(11) Detached from environment										2.26
Mean	2.32	2.19	2.79	2.18	1.97	2.04	3.45	1.14	2.35	2.78

Note: $N = 191$. Data are based on Confirmatory Factor Analysis. Standard deviations are presented along the main diagonal.

These data show that the TIS has several factors that can be confirmed as important in the specification of reactions of tonic immobility in sexual assault in females. Fusé and colleagues used these data to construct a figure which shows the significant aspects of TI in female sexual assault victims and is a good guide to assessing victims of sexual assault. The dimensions of these findings, as seen below, are important to our understanding of tonic immobility and its human considerations. Though only females were used in this study and assertions can't be made about gender differences, we can confirm that TI is an important indicating factor in severity of assault, level of fear, and is certainly associated with sexual assaults.

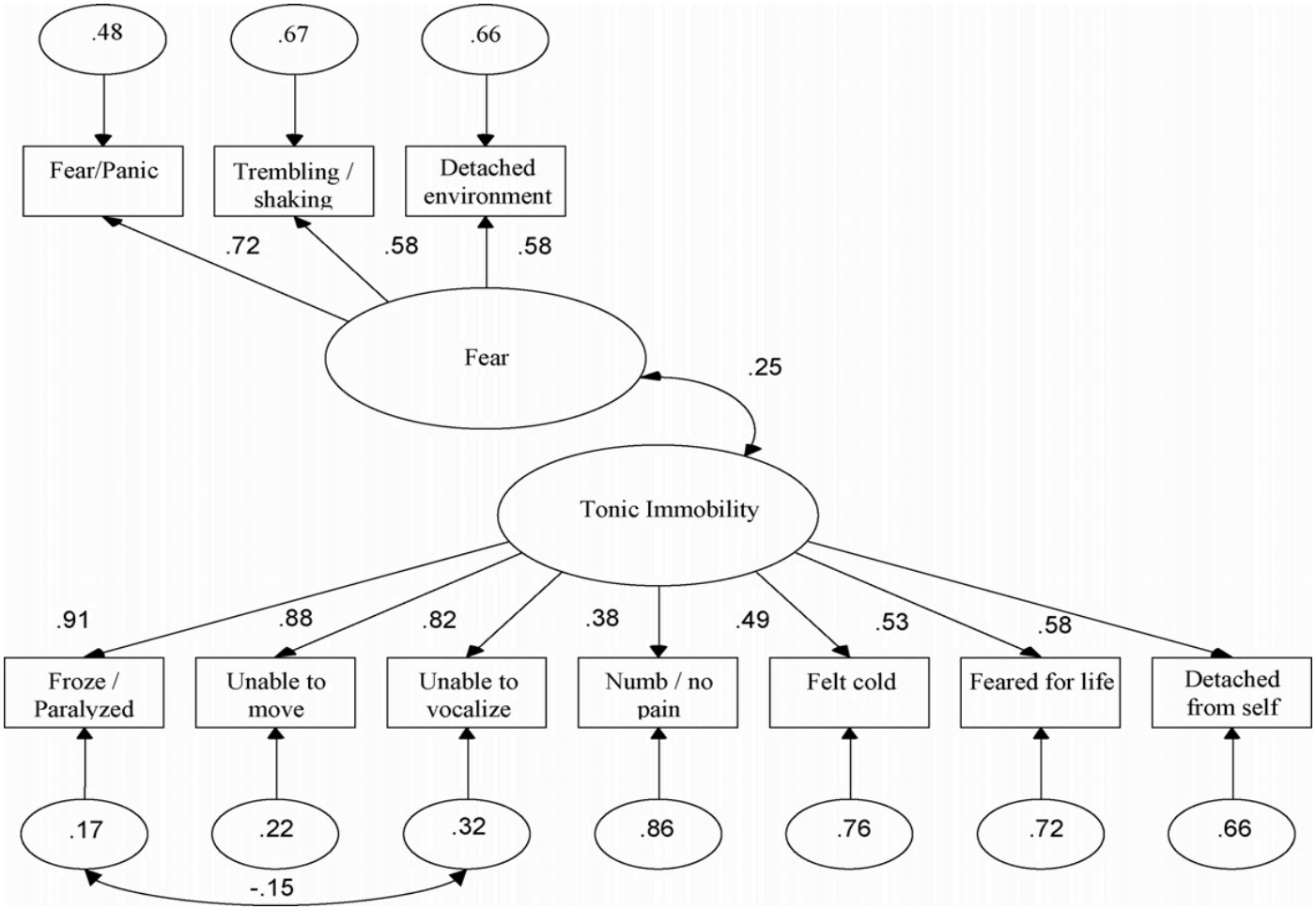

Figure 10. The Relationship of Significant Factors in the TIS. This figure was created from the data obtained in the study *Factor structure of the Tonic Immobility Scale in female sexual assault survivors: An exploratory and Confirmatory Factor Analysis* and shows confirmation of the generalization of these factors tested on the TIS in female sexual assault vitcims. (Figure from Fusé et al., 2007).

The last study we are going to review was performed in 2010 and brings together many of the ideas we have already explored. *Tonic Immobility in Childhood Sexual Abuse Survivors and Its Relationship to Posttraumatic Stress Symptomatology* was conducted by Karen Humphreys and associates and studies the aspects of tonic immobility we have previously investigated such as its relationship to sexual abuse and its indicative value in PTSD symptomology. The main hypothesis of this study is that TI will mediate symptom severity of PTSD specifically in female sexual assault survivors. To test their hypothesis Humphreys and her colleagues used 131 college undergraduates who indicated they were victims of childhood sexual assault, with some experiencing adult sexual assault, as participants. All participants were female and they were given a Posttraumatic Diagnostic Scale to assess PTSD severity and TI was assessed using the Tonic Immobility Scale- Child Form, and the abbreviated form of the LEQ, Life Experiences Questionnaire, to assess degree of CSA. The information used from these questionnaires was compared to determine how the presence of tonic immobility during a childhood sexual assault mediates the experience of PTSD in an adult. The results from this study found very significant evidence that intense fear felt during a childhood sexual assault correlates to the expression of TI and later can be predictive of severity of PTSD in adults. Some of the data from this study can be found below.

Table 7. Data from: *Tonic Immobility in Childhood Sexual Abuse Survivors and Its Relationship to Posttraumatic Stress Symptomatology.* This table shows the correlational relationship between TI, PTSD symptoms, and the four factors that measure outcome. (Table from Humphreys et al. 2010).

Variable	2	3	4	5	6
1. Fear	.51***	.33***	.27**	.37***	.27**
2. TI	—	.33***	.35***	.30***	.27**
3. PDS total		—	.89***	.92***	.93***
4. Reexperiencing			—	.74***	.73***
5. Avoidance/numbing				—	.77***
6. Hyperarousal					—

Note: TI = tonic immobility; PDS total = total posttraumatic stress disorder score as assessed by the Posttraumatic Diagnostic Scale; reexperiencing = reexperiencing symptoms as assessed by the Posttraumatic Diagnostic Scale; avoidance/numbing = avoidance and numbing symptoms as assessed by the Posttraumatic Diagnostic Scale; hyperarousal = hyperarousal symptoms as assessed by the Posttraumatic Diagnostic Scale. *N* ranged from 120 to 127.
$^{**}p < .01$. $^{***}p < .001$.

The findings of this study are meaningful because they confirm many of the conclusions from previous studies, such as the validity of TI in childhood and adult sexual assault, as well as its predictive value in diagnosing the severity and symptomatology of PTSD. The deductions of this study and of the other studies previously detailed lead us to an important acknowledgement about the nature of tonic immobility. As we know, tonic immobility is an unconscious response elicited by the body that commonly arises in situations that are perceived as life-threatening and where restriction is used by an attacker, either physically or by verbal threats. Tonic immobility arises as a final defense mechanism when the danger is perceived to be too great for fighting or fleeing, such as in the case of sexual assault, especially childhood sexual assault. The feelings associated with this intense response correlate strongly with later symptoms of post-traumatic stress

and cause victims to feel depressed, anxious, and have an exaggerated stress response in future tense situations. All of this helps us to understand better the degree of trauma experienced by sexual assault victims as well as why they react the way they do and what consequences this will have on the way they later re-experience these traumatic incidences. The previous studies helped us to clarify these inferences, which supplement information on our hypothesis as well as provide an interesting avenue to explore in gender differences. The last three studies, and some of the other studies used to review our topic, used all or significantly greater numbers of females as there participants. This leaves many inquiries illuminated for us about tonic immobility and gender, which will we continue to investigate in our present discussion.

Discussion

It was our aim to look at how the sympathetic nervous threat response may vary depending on gender. We have explored the fundamentals of sympathetic response with an emphasis on tonic immobility starting with primary research on animal behavior. The very first literature we discussed found various levels of tonic immobility in many different animals, depending on factors like position, level of fear, and restraint. The researchers Suarez and Gallup, who worked primary with animals and TI, developed the hypothesis that TI could exist in females during rape due to its similarity to life-threatening situations in the animal kingdom. After a period of time studies began to focus on TI as a fear response in humans, though most researchers used female participants only. Tonic immobility does exist in males as well. TI was observed in animals of both sexes initially and substantiated by findings in studies that included male participants. Once TI was established for both genders, we looked at how each gender responded to stress and found variations in both HPA axis as well as reactions to trauma. Discussing parallel ideas about the HPA axis, SAM system, and stress as compared to gender helped us to set up a basis for the conclusion of our hypothesis. Findings from studies we looked at here, which considered gender variations in long-term stress, did provide evidence that differences exist, not only anatomically and hormonally, but also psychologically. These conclusions were important but not definitive for one generality about gender and stress, which gave us a foundation for our work here without a specific direction. We then went on to look at some of the situations in which TI arises in humans, types of trauma with implications for PTSD severity and symptomology.

Studies exploring TI, trauma, and PTSD also found a correlation between the experience of peritraumatic TI and a future PTSD diagnosis. Those studies gave us direction to explore some of the most recent research in TI, which involves sexual assault on females, assessing tonic immobility, and posttraumatic stress disorder. The last three studies we explored solidified many of the factors in TI that we had previously found to be important, while focusing on how the relationship between TI, sexual assault, and PTSD can be highly correlated. Again, most of these studies focused on females.

Psychologically these findings help us to assess and understand sexual assaults and the peritraumatic experience, as well as the consequences of this trauma such as depression, anxiety, and PTSD. Culturally we can use this information to help develop a better awareness of why people react and behave the way they do in circumstances we may not be familiar with. Judicially we can change how we view crimes and victims, as many court cases have shown that not fighting back in a sexual assault may be argued to be consent (Freyd, 2008). Our specific goal here, of finding if the tonic response is preferred in females, is difficult because some of the most recently conducted studies only focus on TI as it relates to sexual assault in females, with little data on males and TI. While it is tempting to determine that our hypothesis has been unconsciously acknowledged as conclusive, it would be premature to make this assumption without first discussing why this topic evolved the way it has. Why are females so much more prone to be victims of interpersonal violence? Is it simply a matter of physical size and strength? Do androgens such as testosterone affect behavior so significantly? Or should we focus on anthropology and determine if certain societies are more prone to victimize

women? The issue of why women are more often targets of violence and sexual assault is a multi-faceted topic worthy of a complete review in and of itself, and one which is explored in the World Health Organizations publication: Social determinants of sexual and reproductive health (2010). It is mentioned here because before coming to a conclusion on our topic it seems important to take a step back and consider a broader view on the ideas discussed here, not only through the review of literature on the topic, but also on why that literature took such a specific focus to begin with.

We know the sympathetic nervous response occurs in fearful and life-threatening conditions. We know that tonic immobility occurs as a response when fear is extreme and restraint is involved, sometimes as a last response in a hierarchy, sometimes sooner. One could say that because females are generally smaller, they are more vulnerable to these parameters and thus to a tonic response. Is TI then a function of size and vulnerability or gender specifically? If a small male is attacked by a much larger male, would his reaction then tend towards TI or would he engage in a fight or flee the situation? What if a human of either gender was attacked by a sizeable grizzly bear, the example so frequently given in science classes, how would the sympathetic response of each be dictated by their gender? There are many situations we can theoretically consider to demonstrate that our assertions here about the biological response of humans can be complex, especially when considering gender differences.

Conclusion

In the review of this topic it would appear that the sympathetic nervous response of tonic immobility is favored in females in specific cases, such as interpersonal violence. This is a tentative conclusion since data on male TI and interpersonal violence has been so sparse. We did determine that tonic immobility occurs most often in situations that are life-threatening and involve restraint, or being physically overpowered, which is a more common phenomenon in females. To truly determine if females experience more TI than males, it would be necessary to make a direct experimental comparison of gender and the experience of TI. Though it was our aim here to use previous studies to determine gender differences in the sympathetic response, the lack of information on men leaves us unable to determine why researchers consider more females to experience TI, to the point where it was initially thought that TI occurred in females exclusively. It could be something structurally or hormonally induced, it could be adaptive for females, or perhaps TI is manifested in certain contexts that are purely situational. It seems that TI was previously thought to occur in situations of sexual violence, an experience women are more prone to suffer. We now know that TI occurs in both genders and under various circumstances. It is our belief here that because females are generally less physically adroit than males and more prone to interpersonal violence, that it would be adaptive in violent, especially sexually violent situations, to induce tonic immobility to enhance survival in a situation where fighting or trying to flee would be deadly. This is a conclusion drawn from ideas on evolutionary psychology, however, and no definite conclusions about gender can be drawn without further research on this topic.

Future Areas for Research

An obvious route that areas of future research could take would be to explore the ideas in our review directly with laboratory or clinical studies comparing experiences of TI to gender. Though we found some previous research for an indirect comparison of genders with regard to a tonic response, it would help to more clearly illuminate the origin of a difference if a direct study was done. There are many questions this review has uncovered which bear the need for further research. Examples of these questions would be: Is TI favored biologically, or if males were put in a similar situations as females in regard to extreme fear and restraint, would they exhibit more TI? If TI is favored in females, what implications does this have for occupations in which trauma is experienced regularly and the opportunity to become tonic is frequent, such as fire fighters, EMT's and police officers? If one experiences TI in the occupations previously listed, what effect will that have? If TI is favored: what elements of gender would make TI a more favored response; is it biological, psychological, cultural?

All of these questions could be explored in new studies that could take a step back from the focus of tonic immobility in sexual assaults on females. Though those studies helped us to draw our assertions here about gender and TI, it would now be pertinent to verify our conclusions both experimentally and on different levels of the topic by exploring if the validated factors of TI, such as restraint and extreme fear, equally induce TI in different genders, ages, and those with varying levels of psychological health.

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