Boston University

OpenBU **http://open.bu.edu**

Boston University Theses & Dissertations Boston University Theses & Dissertations

2024

Comparison of language and somatic experiences between reports of trauma and trauma-related dreams & personality features of trauma-exposed persons reporting trauma-related dreams

https://hdl.handle.net/2144/49048

Downloaded from DSpace Repository, DSpace Institution's institutional repository

BOSTON UNIVERSITY

ARAM V. CHOBANIAN & EDWARD AVEDISIAN SCHOOL OF MEDICINE

Thesis

COMPARISON OF LANGUAGE AND SOMATIC EXPERIENCES BETWEEN REPORTS OF TRAUMA AND TRAUMA-RELATED DREAMS & PERSONALITY FEATURES OF TRAUMA-EXPOSED PERSONS REPORTING TRAUMA-RELATED DREAMS

by

KIMBERLY LYNN HICKEY

B.A., B.M., Oberlin College & Conservatory, 2022

Submitted in partial fulfillment of the

requirements for the degree of

Master of Science

2024

© 2024 by
KIMBERLY LYNN HICKEY
All rights reserved

Approved by

First Reader ______________________________

Vickery Trinkaus-Randall, Ph.D.
Professor of Biochemistry & Cell Biology

Second Reader ______________________________

Edward Pace-Schott, Ph.D.
Associate Professor of Psychiatry

COMPARISON OF LANGUAGE AND SOMATIC EXPERIENCES BETWEEN REPORTS OF TRAUMA AND TRAUMA-RELATED DREAMS & PERSONALITY FEATURES OF TRAUMA-EXPOSED PERSONS REPORTING TRAUMA-RELATED DREAMS

KIMBERLY LYNN HICKEY

ABSTRACT

Introduction: *(Study A)* Trauma-Related Nightmares (TRNs) are a core feature of Post-Traumatic Stress Disorder (PTSD). We explored linguistic and somatic-experience differences between self-reports of trauma and those of nightmares related to the trauma. *(Study B)* Neurotic personality features are associated with many psychological disorders, including PTSD. Based on this relationship, we explored whether neuroticism predicts the rate of nightmares and bad dreams as well as the number of replicative nightmares (TRNs similar or exactly like their traumatic experience), above and beyond PTSD severity.

Methods: *(Study A)* Seventeen participants with varying severity of PTSD symptoms reporting recurring TRNs (mean age 27.47 years, SD = 10.33, 14 females) recalled a traumatic experience and nightmares related to that trauma. Trauma reports were written by participants, while nightmare reports were transcribed from audio recordings made as they were recalled following nightmares. Following both types of reports, participants indicated co-occurring somatic experiences by choosing from a list of 51 selections. Choices were later grouped into cardiovascular, respiratory, interoceptive, and tension

categories. Linguistic content was measured using the Linguistic Inquiry and Word Count (LIWC) program and positive emotion, negative emotion, and somatosensory category words were totaled. Since trauma reports had significantly higher word counts than TRNs (p=0.0495), LIWC categories were normalized for total word count. Total and symptom-cluster severities of PTSD were assessed using the PTSD Checklist for DSM-5 (PCL-5). Wilcoxon Signed-Rank Tests and Spearman Correlations were used for statistical analysis, as Shapiro-Wilk tests showed that data were non-normally distributed.

(Study B) 126 participants who had experienced a traumatic event within the past two years were recruited (mean age 24.13 years, SD = 4.994, 69% female) and, for an average of 14.89 nights, completed a dream questionnaire on which occurrence of nightmares (causing awakening) and bad dreams were reported and ranked based on their similarity to their recent traumatic experience. PTSD symptoms were assessed using the PCL-5 and personality features such as neuroticism were measured using the NEO Personality Inventory Revised (NEO PI-R), a questionnaire based on the Five Factor Model of personality. The combined number of nightmares and bad dreams was divided by the total number of nights reported and expressed as a rate, while a replicative nightmare count was generated by summing “similar to traumatic experience” and “exactly like traumatic experience” ratings. Hierarchical regressions were used to determine whether neuroticism predicted the rate of nightmare and bad dreams as well as the number of replicative nightmares above and beyond PTSD severity. Pearson correlations were used to check for relationships between variables and possible collinearity.

Results: *(Study A)* There were significantly more somatic experiences of interoception (p=0.0084) and tension (p=0.024) in trauma vs nightmare reports. The intrusion cluster of the PCL-5 was associated with cardiovascular (rho=0.592, p=0.0156) and respiratory (rho=0.619, p=0.0109) experiences in trauma reports, and interoception (rho=0.718, p=0.0033) and tension (rho=0.556, p=0.0224) experiences in nightmare reports.

(Study B) In two hierarchical regression models, neuroticism predicted neither nightmare and bad dream rate nor number of replicative nightmares over and above total or PTSD symptom cluster severity (p=0.596; p=0.886). Collinearity checks did demonstrate a moderate positive relationship between these variables (r=0.317, p<0.001).

Conclusion: *(Study A)* More somatic experiences of interoception and tension were recalled from traumas than TRNs. Because the brain is deafferented from sensory input during dreaming, we expected, but did not find, state differences in other somatic experiences. Word categories in narratives also did not show state differences. Only the intrusion symptoms of PTSD predicted bodily sensations in trauma as well as TRN reports.

(Study B) We found that neuroticism did not predict either nightmare and bad dream rate or the number of replicative nightmares above and beyond PTSD severity, when taking demographic factors into account. The positive correlation between PTSD and neuroticism could explain this lack of significance.

Support: R21MH128619

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABP…………………………………………………………………..Arterial Blood Pressure

BP……………………………………………………………………………..Blood Pressure

CAPS-5…………………………………Clinician-Administered PTSD Scale for DSM-5

CBT……………………………………………………………...Cognitive-Behavioral Therapy

CO2……………………………………………………………………..Carbon Dioxide

DSM-IV………….Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition

DSM-5……………..Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition

EEG…………………………………………………………………Electroencephalogram

EMSQ…………………………………………….. Evening/Morning Sleep Questionnaire

EPQ…………………………………………………………Eysenck Personality Questionnaire

HR………………………………………………………………………………Heart Rate

LIWC…………………………………………………….Linguistic Inquiry and Word Count

NEO PI-R……………………………………………….NEO Personality Inventory-Revised

PCL-5……………………………………………………………PTSD Checklist for DSM-5

PTSD……………………………………………………Post-Traumatic Stress Disorder

REM……………………………………………………………………Rapid Eye Movement

RTN……………………………………………………………...Reticular Thalamic Nucleus

SCID-5……………………………………Structured Clinical Interview for the DSM-5

SCISD…………………………….Clinical Interview for DSM-5 Sleep Disorders Module

SDI…………………………………………………………………….Script Driven Imagery

TMS………………………………………………………Transcranial Magnetic Stimulation

TRN……………………………………………………….. Trauma-Related Nightmare

INTRODUCTION

Post-Traumatic Stress Disorder (PTSD) is a psychiatric illness caused by traumatic experiences, such as sexual assault, rape and intimate partner sexual violence, stalking, injury, and sudden death of a loved one (Kessler et al., 2017). Although traumatic events are a common experience worldwide, an estimated 70% of the global population (Benjet et al., 2015), only approximately 6.8% of the US population meet criteria for a PTSD diagnosis (Harvard Medical School, 2007), while countries in Europe, Asia, and Africa show lower prevalence of PTSD (Atwoli et al., 2015).

Those with PTSD often re-experience their traumatic events through nightmares, flashbacks, and intrusive thoughts and memories. They often avoid thoughts, feelings, people, and/or places that are associated with trauma, experience mood changes, and struggle to recall aspects of their traumatic experiences. They commonly present with symptoms of hyperarousal and hypervigilance such as irritability, impulsivity, attention deficits, and sleep disturbances (Lancaster et al., 2016).

TRAUMA-RELATED NIGHTMARES

Trauma-Related Nightmares (TRN) are a well-established fundamental characteristic of Post-Traumatic Stress Disorder (PTSD) (Campbell & Germain 2016). Meta analyses reveal that approximately 60-70% of those diagnosed with PTSD experience frequent and persistent nightmares that often do not improve following treatment (Krakow et al., 2002; Kilpatrick et al., 1998). TRNs occur mostly during the rapid eye movement (REM) stage of sleep, during which, loss of muscle tone, brief and involuntary twitching of muscles, and activation in the cortex (Blumberg et al., 2020), however 25% of them occur in non-REM sleep (Solms 2011). Simos & Berle 2023 pose that experiencing post-traumatic nightmares guides individuals in processing traumatic events by reliving them. The current body of research involving PTSD and nightmares clearly highlights a strong association between severity of PTSD symptoms and nightmare frequency (Wakschal et al., 2018).

Limited data has been published directly comparing reports of traumatic and nightmare experiences. However, the concept of eliciting emotions and physiological responses through participant narratives, also known as script-driven imagery, has been well-studied in PTSD as well as other disorders and affective states (Hopper et al., 2007; Barkay et al., 2012). Participant scripts are transformed into standardized script-driven imagery (SDI) narratives, written in second-person present tense, and includes several contextual details that may not have been in the original narrative: somatic experiences, behaviors, thoughts, location, date, time, etc. (Bujarski et al., 2015). A different set of participants then listen to these standardized narratives and imagine that they are embodied in the narrative.

The literature that does exist surrounding reports of trauma and TRNs, through script-driven imagery, have shown that physiological measures of stress (skin conductance, heart rate, and corrugator electromyography data) were increased in both trauma and TRN scripts significantly from baseline, but not between trauma and nightmare scripts (Mendelsohn et al., 2022). A preprint study by McGrory et al., 2023 reinforced this result, finding no significant difference between trauma and TRN script driven imagery narratives regarding emotional reactivity.

LINGUISTIC ANALYSIS OF TRAUMA AND TRN REPORTS

The Linguistic Inquiry and Word Count (LIWC) program is often used in neuropsychological research for analyzing text and counting various words categorized into different categories based on a standard dictionary (Chung & Pennebaker 2018). It analyzes texts by comparing words to the predetermined word categories in the dictionary chosen and generating a frequency of total words in the text that fall under these various categories. Some of these word categories are “emotion,” of which is comprised of “positive emotion” and “negative emotion,” which both are comprised of different sub-categories such as “optimism and energy” and “anger.”. They additionally include sensory somatic words such as “seeing,” “hearing,” and “feeling” categories (Pennebaker & Francis 1999). In research, the LIWC is commonly used to assess emotional expression, physical states, dreams, and PTSD narrative stimuli.

The LIWC can be used as an objective measure to examine the magnitude of affective states in autobiographical narratives, particularly in emotional expression. One study sought to test whether the LIWC truly measures the verbal (transcribed) expression of emotion in participants. They found through multiple experiments that LIWC emotional frequency output based on emotional autobiographical narratives matches participants’ subjective and momentary emotional self-report, elicited by films with various affective valences (Kahn et al., 2007).

However, it is unclear if there is a true association between LIWC valences of emotion and self-reported emotion as there are inconsistent findings. Other studies have shown that there is no clear correlation between LIWC positive and negative emotion categories and self-reported positive and negative emotions (Bantum & Owen, 2009; Owen et al., 2006; Tov et al., 2013). The LIWC has been compared with human raters as well and shown to be useful in predicting positive and negative emotions, although even more effective when paired with human ratings (Schaefer Ziemer & Korkmaz, 2016). Some data reports that although the LIWC is accurate in measuring overall emotional states, specific emotions such as anxiety and anger are not as accurate as subjective measures or human raters (Alpers et al., 2005; Bantum & Owen, 2009).

One study used the LIWC, measuring the frequency of various emotional states, between waking and dream autobiographical narratives. They found that there were no differences in negative emotion words between waking and dream states, reflecting previous findings (Hawkins & Boyd, 2017). Supporting this, Bulkeley & Graves (2018) found that although dream reports showed higher number of nonaffective word categories such as past-tense words and pronouns, dream reports had low number of affective word categories.

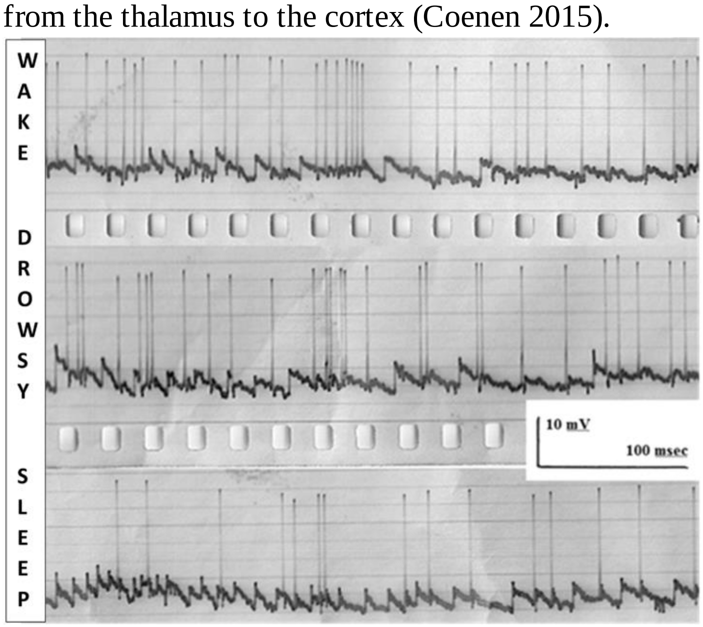
Guzick et al., 2024 utilized LIWC to analyze written traumatic experiences, later translated into script driven imagery (SDI), and compared them with high-frequency deep transcranial magnetic stimulation (TMS). Although TMS reduced PTSD severity significantly more than SDI, it decreased PTSD symptoms more than control or other PTSD treatments such as cognitive-behavioral therapy (CBT). Using the LIWC, they examined the “negative emotion,” “authenticity,” and “cognitive processing” word categories found in PTSD trauma scripts and found that more negative emotion words were associated with lower PTSD severity, as determined by both self-report and clinician ratings (Guzick et al., 2024).

In addition to affective word categories, the LIWC also assesses physical and somatosensory factors such as “feeling,” “hearing,” and “seeing.” Text analysis has been compared with human ratings in predicting psychological and physiological aspects of health in patients currently suffering from chronic pain (Ziemer & Korkmaz, 2017). Participants were asked to provide two different narratives, one regarding their thoughts and feelings about experiencing chronic pain from a self-compassionate frame, and another regarding their experience with chronic pain management and how effective they felt treatment has been. They found, when compared to subjective human ratings, LIWC measures of psychological and physiological features were not as accurate as human ratings. However, of note, the only somatic word category used from the LIWC was “biological processes.” No data was found comparing somatosensory or somatic experiences measured by the LIWC with more objective physiological measures (skin conductance, heart rate, blood pressure, etc.) nor self-reported somatic states.

The LIWC has been used to examine the frequencies of affective states in both traumatic and dream narratives, however a direct comparison of the two has not yet been established in the current body of literature. Somatosensory features of the LIWC have not yet been explored in autobiographical narratives.

The thalamus, a brain region located in the center of the brain, contains mostly gray matter made up of cell bodies which project sensory and motor information from the body to the cortex (Torrico & Munakomi, 2023). On the dorsal side of the thalamus lies an important structure, the reticular thalamic nucleus (RTN), which controls the thalamus, modulates how much sensory information is projected to the cerebral cortex. The reduction of sensory information to the cortex, through the inhibitory actions of the RTN on the thalamus, is responsible for the onset of sleep and is referred to as "sensory gating" (Coenen 2024; McCormick & Bal, 1994).

Figure 1. Comparison of Thalamocortical Neuronal Activity Between Wakefulness, Drowsiness, and Non-REM Sleep. The phenomenon of "Sensory Gating" is shown via electrophysiological membrane potentials of feline thalamocortical relay neurons in response to a light stimulus, during wakefulness, drowsiness, and non-REM sleep. We see that in non-REM sleep, there is a decrease in communication of sensory information from the thalamus to the cortex (Coenen 2015).



SENSORY GATING AND SENSORY DEAFFERENTATION

This concept of sensory gating was first explored by Coenen and Vendrik in the early 1970s. Through investigating the modulation of visual sensory information from the eyes to the cortex in cats, they found that during states of wakefulness, all afferent information to the cortex was modulated by the thalamus. However, during non-REM sleep, only approximately one-third of sensory information reached the cortex, due to the inhibitory actions of the RTN on the thalamus (Coenen & Vendrik, 1972; Hennevin et al., 2007). Supporting this theory, in humans undergoing general anesthesia, somatosensory thalamic neurons were highly active during sleep and inactivated upon awakening (Tsoukatos et al., 1997).

Since the 20th century it is thought that another theory, the "reticular brainstem" theory, plays a role in sleep onset and maintenance. This theory suggests that the reticular brainstem or the reticular formation, which is a collection of neurons and nuclei found in the brainstem, when activated, reduces environmental sensory stimuli and triggers sleep (Coenen 2024). Now, it is thought that both the reticular brainstem and sensory gating theories both play important roles in the transition from wakefulness to sleep.

SOMATIC EXPERIENCES DURING SLEEP

Not all sensory activity, though, is inhibited from reaching the cortex and there are some senses that are relatively preserved. Visual, auditory, and somatosensory sensory inputs demonstrated to be quite preserved, as their membrane potentials were essentially identical between REM and waking states and were markedly lower in the potentials measured during non-REM sleep, suggesting that the neuronal activity that occurs during REM sleep is similar to waking and greater than in non-REM sleep (Coenen 2024). Sleeping participants were able to recognize their own name and can encode basic learning tasks, however, show to be difficult to retain upon waking (Oswald et al., 1960; Perrin, 1999; Züst et al., 2019; Coenen & Drinkenburg, 2002; Ruch et al., 2022).

Emotional processing also seems to be retained during sleep. Corsi-Cabrera et al., (2016) found that during REM sleep, the amygdala shows increased neuronal firing than during waking moments. The amygdala plays a significant role in producing a "wake-up call," as it detects unusual stimuli and connects this information through the excitatory actions of the RTN to the thalamus to cause sudden awakening, paired with psychological states such as hypervigilance (Marek et al., 2013; Murray Sherman, 2001).

Current knowledge of the modulation of sensory information via the connection between the RTN and thalamus is limited, however research poses that due to its membrane potential similarity with wakefulness, external sensory information may evade sensory gating (Coenen 2024). Some somatosensory stimuli, such as spraying water or applying pressure on participants, were integrated into their dreams, suggesting that these types of stimuli are able to pass the sensory gate (Dement & Wolpert, 1958; Sauvageau et al., 1998). However, since the processing of stimuli during REM sleep is still different than during waking states, sensory gating is thought to be mostly similar between REM and non-REM sleep (Coenen 2024).

CARDIOVASCULAR AND RESPIRATORY CHANGES DURING SLEEP

Overall, both heart rate (HR) and arterial blood pressure (ABP) decrease significantly during sleep. During non-REM sleep, there is a progressive decrease in sympathetic firing and a progressive increase in parasympathetic firing, reflecting the "rest and digest" functions of the parasympathetic nervous system. The decrease in sympathetic firing causes a reduction of ABP of about 10-20%, and the increase in parasympathetic firing causes a reduction in HR (Silvani & Dampney, 2013; Seravalle et al., 2018). During REM sleep, though, cardiovascular values return to baseline as they are during waking states.

The rapid eye movement distinctive of REM sleep is associated with increased frequency of breathing and shallower breaths and occurs intermittently during this period due to dreaming (Schafer & Schlafke, 1998). This leads to sporadic breathing patterns often with brief pauses in between breaths and periods of shallow breathing, even when there is a high number of carbon dioxide (CO_2) in the blood (Orem et al., 2000; Schafer & Schlafke, 1998). Researchers have found that the chemoreceptor neurons in the brainstem responsible for detecting the presence of CO_2 and help modulate breathing are reduced during sleep, allowing for hypercapnia to occur (Douglas et al., 1982; Schafer & Schlafke, 2001). During REM sleep, the body is less able to increase ventilation necessary to combat hypoxia than when awake. During the transition from wakefulness into sleep and throughout sleep, there is a reduction of upper airway muscle activation, especially prominent during REM sleep, which serves as a risk-factor for obstructive sleep apnea (Mezzanotte et al., 1996).

Tension as a form of sensory stimulus has not yet been explored within the concept of sensory gating. However, some studies have assessed tension type headaches, which are the most common type of headache experienced (Rains et al., 2015). Through using an electroencephalogram (EEG), it was found that tension type headaches do not affect REM sleep or latency, unlike migraine headaches. However, tension type headaches did affect the number of time participants slept as well as the number of time it took for them to fall asleep, how efficient their sleep was, number of movement and awakenings during the night, and decreased their number of slow wave sleep (Drake et al., 1990). It is unclear how tension affects the sensory gating system, facilitated by the inhibition of the thalamus by the RTN.

More is known about changes in interoception during sleep and dreaming. Interoception was originally thought to be “sensations from the interior of the body, especially the viscera” (Sherrington, 1906), however now refers to the mechanisms by which the nervous system “senses, interprets, and integrates” signals from within the body (Quigley et al., 2021). Examples of interoception sensations are thermoception (feeling warm/hot, having a flushed face, feeling hot all over, etc.) and nociception (cramps in the stomach, chest pain, etc.).

It was found that interoception is quite rare in REM sleep and dreaming states (Pace-Schott et al., 2019). This lack of interoception is what leads to some of the physiological phenomena that occur during this sleep stage, such baseline HR and BP as well as erratic breathing patterns (Chokroverty, 2017; Kryger et al., 2017). Therefore, it is thought that interoception is detached during REM and dreaming states.

THE NEUROBIOLOGY OF NIGHTMARES

Although nightmares are one of the core features and are a predictive factor of PTSD, the exact neurobiological underpinnings causing them are largely unknown. Limited findings have shown increased activity in the amygdala, anterior paralimbic areas, medial pons, and thalamus, as well as increased sympathovagal tone, during REM sleep. There is also increased cerebral metabolism, blood flow, glucose and oxygen consumption suggesting that more glucose is needed and utilized during REM sleep (Van Cauter et al., 1997). Contrarily, there is decreased and impaired function in the medial and lateral prefrontal cortices, as well as in the parietal and primary sensory cortices. It is thought that the activity in the amygdala (REM-favoring) and the medial prefrontal cortex (non-REM-favoring) is what modulates the transitions between REM and non-REM sleep. Dreams, and therefore nightmares, are thought to be cognitive manifestations of amygdala hyperactivity in conjunction with hypoactivity of the cortices (Germain et al., 2008). Nightmares were also found to be associated with a decrease in gray matter volume in the amygdala, hippocampus, anterior cingulate cortex, and the insula (Nardo et al., 2015).

Another model of nightmare pathology that has been explored is the neurocognitive model, which theorizes that nightmares are simply the result of fear extinction difficulties (Nielsen & Levin, 2007). During Pavlovian classical conditioning, a feared conditioned stimulus will trigger a conditioned fear response. Fear extinction is the phenomenon that over time, there is a decline in conditioned fear responses when exposed to fear conditioned stimuli (Myers et al., 2006). This is a common pattern amongst those with PTSD in that they have difficulties suppressing fear responses to previously fearful stimuli, within a safe environment (Norrholm et al., 2011). The neurocognitive model of nightmares poses that these impairments in fear extinction while dreaming are interconnected with a neurocircuit consisting of the amygdala, hippocampus, anterior cingulate cortex, brain stem, and hypothalamus (Nielsen & Levin, 2007).

PERSONALITY DIFFERENCES IN PTSD

Personality is thought to be the combination of one's subjective experience with both their conscious and unconscious behavior patterns, experiences, and views (Kernberg 2016). In order to compartmentalize the broad and almost limitless phenomena of personality, the Five-Factor Model of Personality was introduced in the 1960s when Tupes and Christal (1961) pioneered the up-and-coming field of personality. They consistently found five recurrent "factors" when analyzing personality ratings of their participants. It wasn't until the 1980s when these factors are now thought to be fundamental "dimensions" of personality (McCrae & John, 1992).

The Five-Factor Model of Personality is a self-reported assessment that categorizes various personality traits into five different dimensions–also known as the "Big Five": Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to Experience. Soto & Jackson (2020) provide definitions for each of the Big Five: Extraversion is defined as being “assertive and sociable” rather than being “quiet and reserved”; Agreeableness is associated with being “cooperative and polite” rather than “antagonistic and rude”; Conscientiousness is defined as “task-focused and orderly” as opposed to “distractible and disorganized”; Neuroticism is associated with “negative emotions such as anxiety, depression, and irritability, rather than being emotionally resilient”; And lastly, Openness to Experience is defined as “having a broad rather than narrow range of interests, are sensitive rather than indifferent to art and beauty, and prefer novelty to routine” (Soto & Jackson, 2020).

Personality traits have been associated with various psychiatric disorders, such as depression, obsessive compulsive disorder, and personality disorders, and it has been observed that when psychopathological symptoms are treated, the level of these personality features change (Widiger 2011). Studies have found that PTSD is associated with higher self-report scores of neuroticism and lower scores of extraversion, when compared to healthy control and trauma-exposed individuals who do not meet PTSD diagnostic criteria (Fauerbach et al., 2000). Supporting this, Contractor et al., (2016) found that “emotional stability,” which is thought to be the opposite of neuroticism to be lower and most associated with PTSD traits. The other factors, agreeableness, conscientiousness, and openness to experience, were all found to be lower in trauma-exposed individuals compared to healthy controls (Fauerbach et al., 2000).

In research settings, the NEO Personality Inventory-Revised questionnaire is the gold-standard tool of assessing the personality domains described in the Five Factor

Model. This assessment contains 240 items, all rated on a likert scale, that all correspond to traits that are encompassed by the "Big Five" (Lawton et al., 2011). When administered to participants who meet diagnostic criteria for PTSD, results unsurprisingly reflect the same findings from the Five Factor Model's personality analysis of PTSD.

NEUROTICISM AND PTSD

Within the current body of literature, it has been well-documented that neuroticism is associated with PTSD and is a vulnerability factor in the development of PTSD. This is due to the idea that neuroticism increases the likelihood of meeting diagnostic criteria for PTSD as well as PTSD symptom severity, due to their tendencies to have increased emotions, number rehearsing traumatic events, and viewing these experiences as central to their identity (Ogle et al., 2015). Those who rate higher in neurotic personality features were found to portray higher levels of rumination and retention of negative affective autobiographical memories (Muir et al., 2022). Yin et al., (2019) studied Chinese participants after an earthquake and found that those who rated high neuroticism levels were more likely to develop PTSD than the other personality domains.

Many different trauma-exposed populations demonstrate significant associations between neurotic personality traits and the development of PTSD. Cox et al., (2004) sampled a range of different participants who faced various types of traumatic experiences: firefighters exposed to a natural disaster, Vietnam veterans, adults living in urban settings, traffic accident victims, and burn survivors, and found that these participants reported higher rates of neuroticism.

PTSD symptoms manifest differently across different populations and manifest differently between men and women. Peters et al., (2005) examined possible gender differences within PTSD diagnoses and found that there are only gender differences for certain PTSD symptoms using the DSM-IV. Women were more likely to be exposed and react to a stressor (Criterion A of DSM-IV PTSD Diagnosis) and re-experiencing the traumatic event (Criterion B) than their male counterparts. However, for all other criteria (C - Avoidance, D - Negative Alterations in Cognition and Mood, and E - Hyperarousal) men and women were equally as likely to endorse (Peters et al., 2005).

Similarly, there are gender-based differences in personality traits associated with PTSD. Cox et al., (2004) found that after controlling for the different types of traumatic events experienced, neuroticism was significantly correlated with women with PTSD and both neuroticism as well as self-criticism was correlated with men with PTSD.

NEUROTICISM AND NIGHTMARES

In addition to being significantly associated with PTSD, the Five Factor Model personality domain neuroticism has been known to be linked to nightmares, specifically nightmare distress (Schredl & Goeritz, 2019). One study found that even when controlling for comorbid psychiatric disorders such as depression and anxiety, those experiencing frequent nightmares consistently endorse more neuroticism items on the

Eysenck Personality Questionnaire (EPQ), a similar assessment to the NEO PI-R (Li et al., 2010).

These relationships persist over time as well. Schredl & Göritz (2020) sought to explore whether the association between neuroticism and nightmare frequency is stable after 2 years of initial study participation. They found that although nightmare frequency within-subjects tends to be stable over time, nightmare frequency overall decreases as age increases. The changes in nightmare frequency that were observed were directly linked to changes in neuroticism scores over time.

There are also profound behavioral effects that come from highly neurotic individuals who suffer from frequent nightmares. Köthe & Pietrowsky (2001) found that those scoring higher amounts of neuroticism are more negatively impacted by nightmares, more influenced by nightmares, and are more likely to feel distressed and anxious after nightmares, due to frequent rumination characteristic of neuroticism (Lang & O'Conner, 1984).

SPECIFIC AIMS

Trauma-related nightmares (TRNs) are a common feature of Post-Traumatic Stress Disorder (PTSD). However, there is limited data comparing trauma and trauma-related nightmares, especially based on linguistic analysis of autobiographical narratives and somatic experiences between these conditions. The neurobiology of sleep suggests that sensory gating, or the reduction of sensory information to the cortex through the inhibition of the thalamus by RTNs, is responsible for triggering sleep, and modulates what sensory information can and cannot reach the cortex. Neuroticism and its association with the development of PTSD and nightmares is well-established, however lacks clarity if the association with nightmares is impacted and influenced by PTSD symptom severity.

This study aims to examine possible relationships between (1) somatic experiences across nightmare and trauma states, (2) somatic experiences and PTSD symptom severity, (3) Linguistic analysis of trauma-related nightmare and trauma reports using the LIWC program, (4) Linguistic analysis of trauma-related nightmare and trauma reports using the LIWC program and PTSD symptom severity, and lastly (5) whether the Five Factor Model personality domain, neuroticism, adds significant variance to the frequency of nightmares and bad dreams as well as the number of replicative nightmares, when controlling for PTSD severity.

We predict that: (1) Somatic experiences will be stronger during trauma recall due to the sensory deafferentation that occurs during sleep and dreaming; (2) PTSD symptom severity will be positively associated with somatic experiences, especially after recalling traumatic experiences; (3) Positive and negative emotion LIWC word categories will not be significant different across trauma and nightmare conditions and that the somatosensory category will be significantly higher during trauma recall that in nightmares; (4) Negative and somatosensory LIWC word categories will be positively correlated and that positive emotion will be negatively correlated with PTSD severity; (5) Neuroticism personality features will add a significant explanation of variance in both nightmare and bad dream rate and number of replicative nightmares, even when controlling for PTSD severity and demographic factors.

METHODS

Study A. Comparison of Language & Somatic Experiences Between Reports of Trauma and Trauma-Related Dreams

PARTICIPANTS

Seventeen participants with varying severity of PTSD symptoms reporting recurring trauma-related nightmares (TRNs) recalled traumatic experiences and nightmares related to that trauma. These participants were recruited through social media and research websites. Seventeen out of forty participants who gave consent, completed the study. Participants on average were about 27 years old (oldest 54, youngest 19), predominantly White (82.4%) and female (76.5%). Participants were born mostly in the United States (California, New England, Pennsylvania, New Jersey, New York, Ohio, Mississippi), however there were 4 participants who were born internationally (Mexico, Russia, Italy, China).

PTSD presence and severity were determined by whether participants' have experienced a DSM-5 PTSD criterion-A event, with some nightmare content related to the traumatic event, and additionally meeting at least 3 of the 4 diagnostic clusters of a PTSD diagnosis, per the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). A PTSD diagnosis contains a stressor along with 4 different symptom clusters:

A. **Stressor:** Exposure to actual or threatened death, serious injury, or sexual violence in one (or more) of the following ways:
    1. Directly experiencing the traumatic event(s)
    2. Witnessing, in person, the event(s) as it occurred to others

3. Learning that the traumatic event(s) occurred to a close family member or a close friend. In cases of actual or threatened death of a family member or friend, the event(s) must have been violent or accidental
4. Experiencing repeated or extreme exposure to aversive details of the traumatic event(s) (e.g., first responders collecting human remains; police officers repeatedly exposed to details of child abuse)

B. **Intrusion:** Presence of one (or more) of the following intrusion symptoms associated with the traumatic event(s), beginning after the traumatic event(s) occurred:
   1. Recurrent, involuntary, and intrusive distressing memories of the traumatic event(s)
   2. Recurrent distressing dreams in which the content and/or affect of the dream are related to the traumatic event(s)
   3. Dissociative reactions (e.g., flashbacks) in which the individual feels or acts as if the traumatic event(s) were recurring
   4. Intense or prolonged psychological distress at exposure to internal or external cues that symbolize or resemble an aspect of the traumatic event(s)
   5. Marked physiological reactions to internal or external cues that symbolize or resemble an aspect of the traumatic event(s)

C. **Avoidance:** Persistent avoidance of stimuli associated with the traumatic event(s), beginning after the traumatic event(s) occurred by one or both of the following:
   1. Avoidance of or efforts to avoid distressing memories, thoughts, or feelings about or closely associated with the traumatic event(s)
   2. Avoidance of or efforts to avoid external reminders (people, places, conversations, activities, objects, situations) that arouse distressing memories, thoughts, or feelings about or closely associated with the traumatic event(s)

D. **Negative Alterations in Cognition and Mood:** Negative alterations in cognitions and mood associated with the traumatic event(s), beginning or worsening after the traumatic event(s) occurred, as evidenced by two (or more) of the following:
   1. Inability to remember an important aspect of the traumatic event(s) (typically due to dissociative amnesia, and not to other factors such as head injury, alcohol, or drugs)
   2. Persistent and exaggerated negative beliefs or expectations about oneself, others, or the world (e.g., "I am bad," "No one can be trusted," "The world is completely dangerous," "My whole nervous system is permanently ruined")

3. Persistent, distorted cognitions about the cause or consequences of the traumatic event(s) that lead the individual to blame himself/herself or others
4. Persistent negative emotional state (e.g., fear, horror, anger, guilt, or shame)
5. Markedly diminished interest or participation in significant activities
6. Feelings of detachment or estrangement from others
7. Persistent inability to experience positive emotions (e.g., inability to experience happiness, satisfaction, or loving feelings)

E. **Hyperarousal:** Marked alterations in arousal and reactivity associated with the traumatic event(s), beginning or worsening after the traumatic event(s) occurred, as evidenced by two (or more) of the following:
   1. Irritable behavior and angry outbursts (with little or no provocation), typically expressed as verbal or physical aggression toward people or objects
   2. Reckless of self-destructive behavior
   3. Hypervigilance
   4. Exaggerated startle response
   5. Problems with concentration
   6. Sleep disturbance (e.g., difficulty falling or staying asleep or restless sleep)

PTSD symptom severity was measured using the PTSD Checklist for DSM-5 (PCL-5), which is similarly composed of 4 symptom domains: Intrusion, Avoidance, Negative alterations in cognition and mood, and Hyperarousal.

The PCL-5 is a 20-item self-report measure that helps assess whether an individual has experienced a traumatic event, and if so, the severity of PTSD symptoms, within the past month of test administration. These 20 items are measured based on a likert scale (from 0 "not at all" to 4 "extremely") and their scores are summed dependent on what symptom cluster that item is categorized in. For example, Criterion B (intrusion) is measured by the sum of questions 1-5. Criterion B (intrusion) and E (hyperarousal) both include questions regarding sleep/nightmares: "Repeated, disturbing dreams of the stressful experience?" and "Trouble falling or staying asleep?" These two prompts were excluded from the intrusion and hyperarousal symptom clusters as to isolate intrusive and hyperarousal behaviors and thinking from troubles with sleep and dreaming.

Exclusion criteria for study participation included history of psychosis, bipolar disorder, neurodevelopmental disorders (e.g., autism), current suicidal ideation, current substance-use disorder, or engagement with drugs of abuse, sleep apnea, regular uses of benzodiazepines or prazosin.

PROCEDURE

Participants were screened for study eligibility first via telephone interview, followed by an in-person visit, where they wrote an account of a traumatic experience most related to their nightmares and completed a checklist of any somatic experiences they had during the traumatic event. Participants were given a document with the prompt: "Listed below are a number of bodily sensations that people may experience in various situations. Circle all of the responses that you experienced in the situation you just described," with a list of various somatic experiences such as "feel tense all over" and "labored breathing." These sensations were later categorized into 4 categories: tension, respirations, cardiovascular, and interoception. **Tension** sensations that participants could choose from were as follows:

- "Feel Tense all Over"
- "Feel Relaxed All Over"
- "Tension in Forehead"
- "Clenched Fist"
- "Tension in Back"

- “Grit my Teeth”
- “Clenched Jaw”
- “Tension in the Arms”
- “Tightness in the Face”
- “Hands Trembling”
- “Feel Restless”
- “Jittery”

Respiration sensations were listed as:

- “Breathes Faster”
- “Breathes Slower”
- “Even Breathing”
- “Pants”
- “Shallow Breathing”
- “Labored Breathing”
- “Gasping for Air”

Cardiovascular sensations were:

- “Heart Stops”
- “Heart Beats Slower”
- “Heart Beats Faster”
- “Heart Pounds”
- “Heart Skips a Beat”
- “Heart Races”
- “Heart Quickens”

And **Interoceptive** sensations included:

- “Nauseous”
- “Stomach is in a Knot”
- “Butterflies in the Stomach”
- “Cramps in the Stomach”
- “Constrictions in Your Chest”
- “Body Feels Heavy”
- “Whole Body Shakes”
- “Feel Hot all Over”
- “Blood Rushing to Head”
- “Flushed Face”

- “Head Pounds”
- “Feel Warm

These categorizations were determined by research staff based on previously established physiological reactions to traumatic experiences and nightmares and were grouped to visualize trends among the data. Traumatic experiences reported frequently involved relationships, robberies, medical/physical, suicide/loss, police, and sexual traumas.

Participants additionally completed the PCL-5 and the Life Events Checklist for DSM-5 (to examine possible traumatic events in the participants’ lifetime), keeping in mind the traumatic experience related to their nightmares. Participants underwent a urine toxicology screening, to assess possible substance use that could affect accurate results. A clinical interview, using the Structured Clinical Interview for the DSM-5 (SCID-5), the Clinician-Administered PTSD Scale for DSM-5 (CAPS-5), and the Clinical Interview for DSM-5 Sleep Disorders Module (SCISD), was additionally conducted to assess PTSD symptom severity.

The seventeen participants were then monitored for 14 nights and were asked to record dream reports and to complete the checklist of somatic experiences they had upon waking up from the nightmare or from recalling a nightmare the morning after. They were additionally asked to complete the Evening/Morning Sleep Questionnaire (EMSQ), which considers factors such as caffeine intake, exercise, perceived alertness, duration of sleep, and several ratings of vividness, how pleasant/unpleasant, and the emotions they felt during experiencing the dream. Most importantly on the EMSQ, the participants were asked to compare their nightmare to their traumatic event in terms of similarity and relatedness.

These time stamped audio recordings were later transcribed and used for script-driven imagery tasks. Between the relatedness self-report measure on the EMSQ and subjective judgment from research staff (through comparison of nightmare scripts with their corresponding trauma scripts), ultimately two nightmare scripts from every participant were considered to be most related to participants' trauma, or replicable. These two replicable nightmare scripts were averaged and subsequently compared to the one trauma script that participants wrote.

Nightmare scripts were then edited by research staff, excluding any content not directly related to the nightmare like contextual details, such as "I completely forgot that I dreamed last night…" or "...just an argument over my lack of help which illogically makes sense cause I always feel like I should do more to help around the house, but I have work and class a lot…"

Linguistic analysis was conducted using the Linguistic Inquiry and Word Count (LIWC) program. The LIWC analyzes text for specific pre-defined word categories, using a built-in dictionary, and calculates the percentage of these categories in a given piece of text. Some examples of LIWC word categories that were used in our analyses are "positive emotion": happy, pretty, good; "anxiety or fear": nervous, afraid, tense; and "anger": hate, kill, pissed, etc. LIWC output for both trauma and nightmare report content were grouped into 3 variables: "positive emotion," consisting of positive tone, prosocial, power, and affiliation LIWC categories; "negative emotion," including negative tone, anxiety, anger, sadness, conflict; and "somatosensory," grouping visual, auditory, and feeling categories. These groupings were made at the discretion of research staff and were done to observe possible trends in more general categories.

STATISTICAL TESTS

As the LIWC considers the percentage of various word categories found in each script, we first compare the word count of both nightmare and trauma reports. Trauma reports were significantly longer ($p=0.0495$), with average word count of the trauma scripts (297.12 words, $SD=141.15$) being higher than nightmare scripts (194.51 words, $SD=181.69$). To accommodate for this variance, LIWC variables were normalized for word count. Shapiro-Wilk tests showed non-normally distributed data (21 out of 30 variables had $p<0.05$, signifying an abnormal distribution), therefore nonparametric tests (Wilcoxon Signed-Rank Test & Spearman Correlation) were used to analyze these data.

Study B. Personality Features of Trauma-Exposed Persons Reporting Trauma-Related Dreams

PARTICIPANTS

A sample of participants who have experienced a recent traumatic event were recruited to understand how psychological trauma can affect sleep quality, physiology, and fear extinction capacity (the ability to learn not to fear). These participants were recruited through the internet, social media, university websites, affiliated hospitals, local sleep and anxiety disorder clinics, newspaper, and public transportation advertisements. 126 out of 141 participants recruited completed the study, and participants were on average about 24 years old (oldest 40, youngest 18), were predominantly White (64.3%) and female (69%). Recent traumatic events were defined by severe traumatic events that have occurred within the past two years prior to study participation, but not including events that occurred within one month prior. Participants reported an estimation of when their traumatic event occurred within the past two years.

PTSD symptom severity was assessed using the PCL-5, and this study additionally measured participants' personality features. The Revised NEO Personality Inventory (NEO PI-R) is a standard measure of the Five Factor Model of Personality, which assesses a person's emotional, interpersonal, attitudinal, and motivational styles. The NEO PI-R consists of 240 items that, in combination, measure the 5 dimensions of personality: agreeableness, conscientiousness, openness to experience, extraversion, and neuroticism. These 5 domains have various traits that encompass them. For example, agreeableness is measured by traits such as trust, straightforwardness, altruism, modesty, and tender-mildness. The NEO PI-R domain we focus primarily on in this study is neuroticism, which is composed of traits including anxiety, anger, hostility, depression, self-consciousness, impulsivity, and vulnerability. This focus is due to the previously established understanding that PTSD severity and neuroticism is highly correlated. From the PCL-5 data obtained in this study, Criterion B (Intrusion) and E (Hyperarousal) subscale scores were modified, excluding the questions involving sleep and nightmares.

Exclusion criteria for study participation include lifetime history of psychosis, bipolar disorder, sleep disorder (excluding insomnia), neurological conditions, severe medical conditions that could influence sleep patterns, disruptions in circadian rhythm, use of psychiatric medications, current drug or alcohol abuse, and excessive caffeine intake.

PROCEDURE

Potential participants who responded to study advertisements will be contacted and given information regarding the study process and will then be screened via telephone interview to assess inclusion and exclusion criteria. Later, participants underwent in person psychiatric, sleep and medical interviews to confirm eligibility. Participants completed the PCL-5 and reported sleep diaries via the EMSQ questionnaire, where they categorized their dreams into:

- **Nightmares:** a very disturbing dream that *woke you up* while the dream was still going on.
- **Bad Dream:** Very disturbing or unpleasant dream that *did not cause you to awaken*. In other words, a dream that you recall having had earlier in the night before you woke up.
- **Sleep Terror:** A sudden awakening that was accompanied by extreme fear and physical sensations such as a pounding heart. No dream or only a brief image was remembered.
- **Recurrent Dream:** A dream that, when you remember it, gives you the feeling of having dreamed it before.
- **Lucid Dream:** A dream in which you became aware of the fact that you were dreaming *while the dream was still going on*.

They additionally ranked these dreams by how similar the content was to their recent traumatic experience, based on a likert scale: “exactly or almost exactly like the traumatic event,” “similar to the traumatic event,” etc. These two categories specifically (exactly or almost exactly, and similar to traumatic events) were summed to form one of our outcome measures: “replicable nightmares.” Of note, the number of nights reported varied slightly per participant; on average participants reported 15 nights, however some reported only 14. The other outcome measure used in this study was "nightmare and bad dream rate." This variable was calculated by research staff as the total number of nightmares and bad dreams divided by the number of sleep diaries reported, for each participant. Therefore, one of our outcome variables, replicative nightmares, is a numerical count, whereas our other variable, nightmare and bad dream rate, is a rate. Of note, the "replicative nightmares" variable is a numerical count across all of the nights and "nightmare and bad dream rate" is measured as a rate (number of nightmares out of the total number of sleep diaries per participant).

STATISTICAL TESTS

The goal of this study is to assess whether features of personality, namely neuroticism, add a significant explanation of variance in the nightmare and bad dream rate and the number of replicable nightmares experienced, when controlling for PTSD symptom severity as well as demographic information. To do this, we conducted several hierarchical regression models with both dependent variables, nightmare and bad dream rate and number of replicable nightmares. Regressions were constructed with Model 1 consisting of demographic variables (Age, Sex, and Months from Trauma to Study); Model 2 including all factors of Model 1, with the addition of PCL-5 (either total or subscales); and Model 3 including all factors of Model 2, with the addition of a NEO PI-R domain. An example of a hierarchical regression layout is shown here:

Table 1: Hierarchical Regression Model Example. These are used to assess whether Model 3 (Neuroticism) significantly explains the variance observed in the nightmare and bad dream rate (outcome variable), when controlling for PTSD symptom severity (Model 2) and demographic factors (Model 1).

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.179[a]	.032	.008	17.8280280	.032	1.307	3	118	.275	
2	.378[b]	.143	.113	16.8510762	.110	15.079	1	117	<.001	
3	.379[c]	.143	.106	16.9168812	.001	.092	1	116	.763	1.926

a. Predictors: (Constant), monthsfromtraumatostudy, Age, Sex

b. Predictors: (Constant), monthsfromtraumatostudy, Age, Sex, PCL5

c. Predictors: (Constant), monthsfromtraumatostudy, Age, Sex, PCL5, NEOPIRN

d. Dependent Variable: NightmareandBaddreamrate

In addition to these regression models, Pearson correlations were conducted between various variables to confirm relationships secondary to results from the hierarchical regressions.

RESULTS

Study A. Comparison of Language & Somatic Experiences Between Reports of Trauma and Trauma-Related Dreams

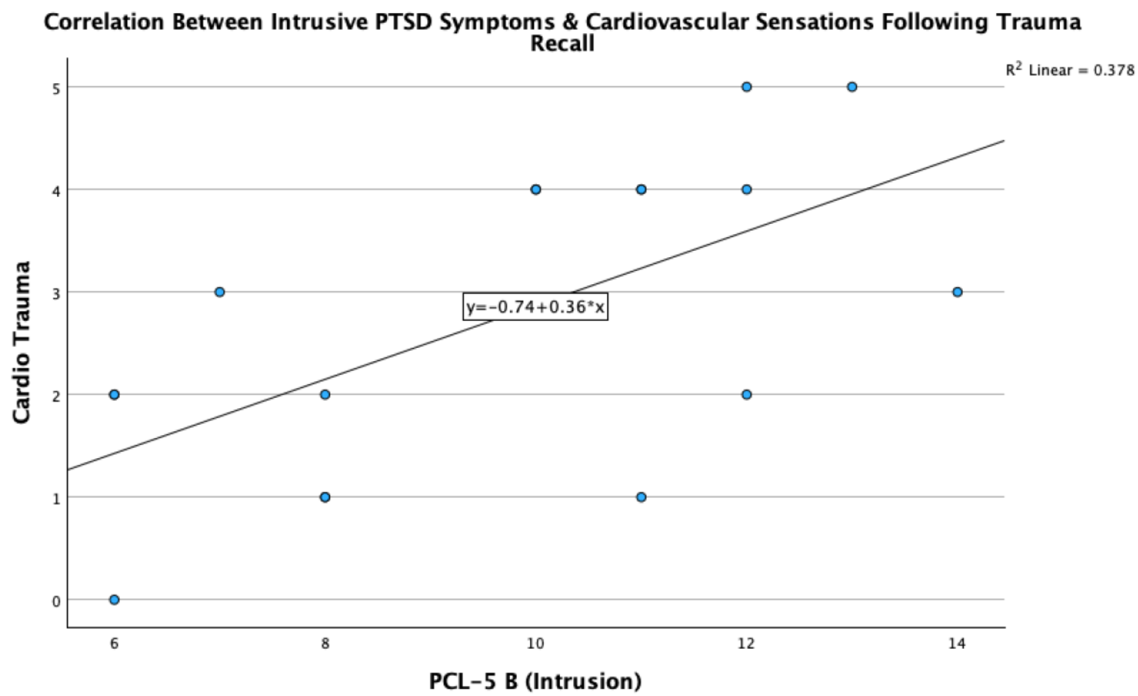
Wilcoxon Signed-Rank Tests were conducted (due to abnormal distribution) to assess if there is a significant difference between the means of different variables of the LIWC word categories and somatic experiences between nightmare and trauma reports, within subjects. A Spearman Correlation Matrix was created to assess possible associations between somatic experiences and LIWC word categories with PTSD symptom severity (as measured by PCL-5), for both trauma and nightmare conditions.

SOMATIC EXPERIENCES

Per Wilcoxon Signed-Rank Tests we found significant differences for Interoceptive experiences between trauma and nightmare conditions. Participants experienced more feelings of being aware of their internal state during recalling their traumatic event than when recording their nightmares ($p<0.01$). We also found differences across trauma and nightmare conditions in Tensive somatic experiences. Participants felt generally more tense when writing about their trauma than when reporting nightmares ($p<0.05$). Neither cardiovascular nor respiration experiences were significantly different across conditions of trauma and nightmare reports.

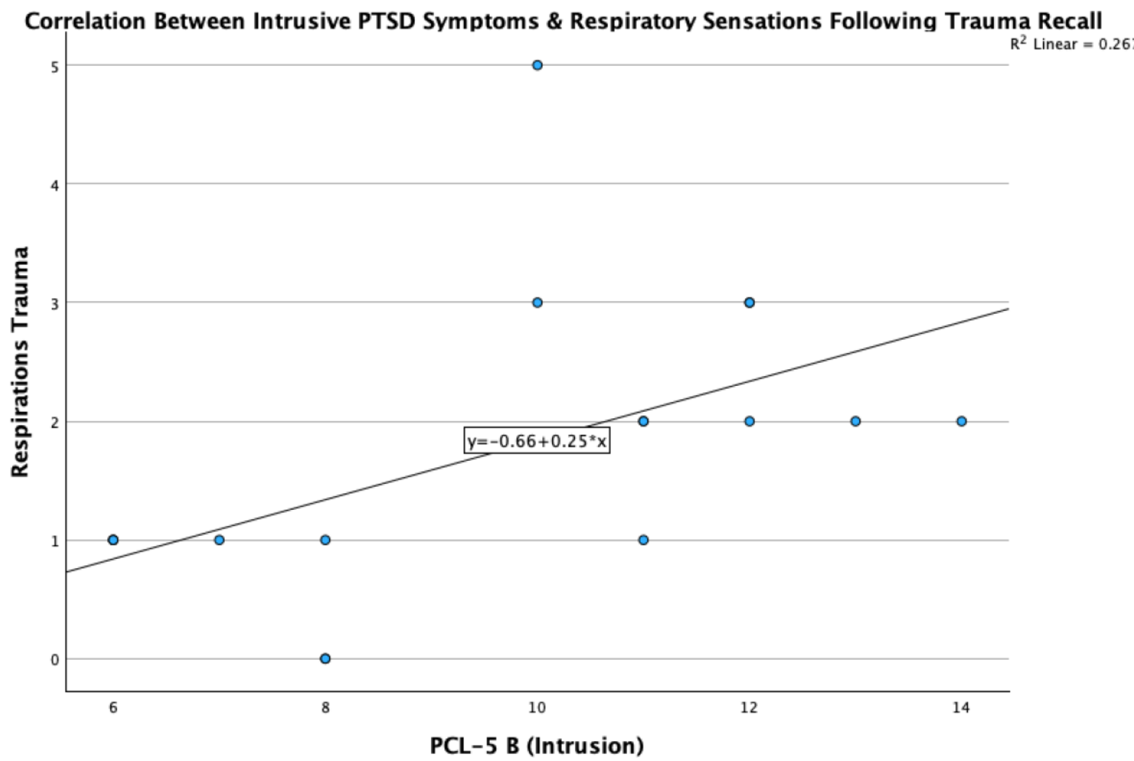
From analysis of the Spearman Correlation Matrix, we found significant associations between certain somatic experiences and PTSD severity. Interestingly, overall PTSD symptoms (PCL-5 total score) showed no significant associations with any of our somatic experiences. However, when separating the PCL-5 into its subscales, we find positive correlations between bodily sensations and the Intrusion cluster of the PCL-5. Intrusive PTSD symptoms were positively correlated with Cardiovascular experiences after writing trauma reports (*r*=0.592, *p*=0.012).

Figure 2. Correlation Between Intrusive PTSD Symptoms & Cardiovascular Sensations Following Trauma Recall.



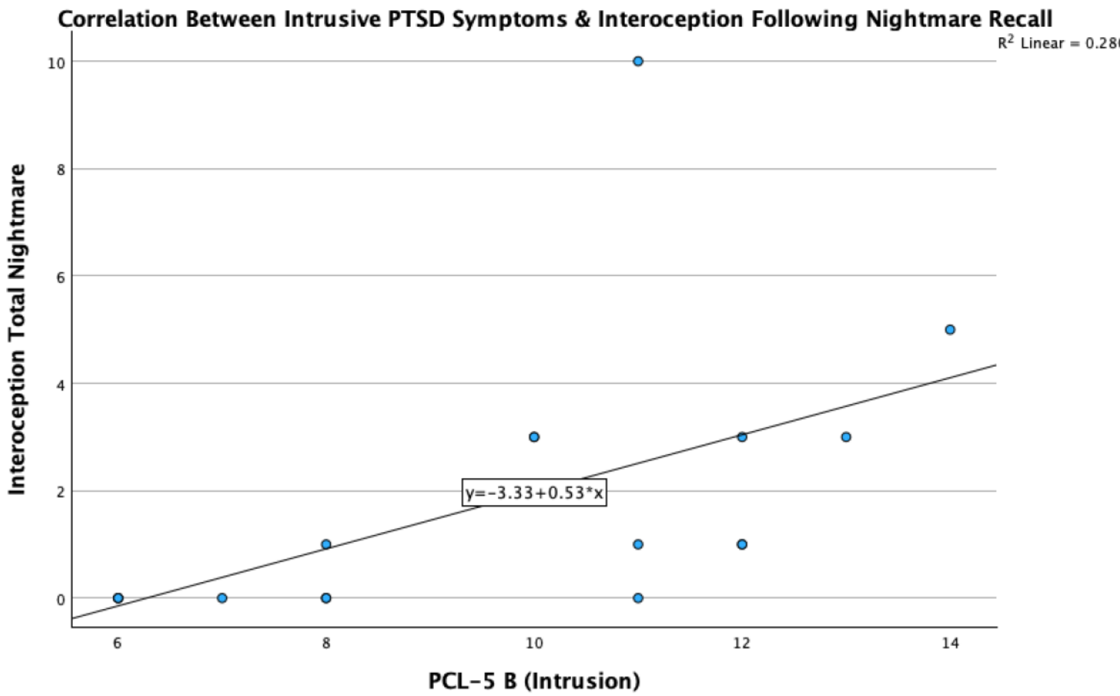
Intrusive PTSD symptoms were additionally positively correlated with Respiration experiences after recalling participants' traumatic events (*r*=0.619, *p*=0.008).

Figure 3. Correlation Between Intrusive PTSD Symptoms & Respiratory Sensations Following Trauma Recall.



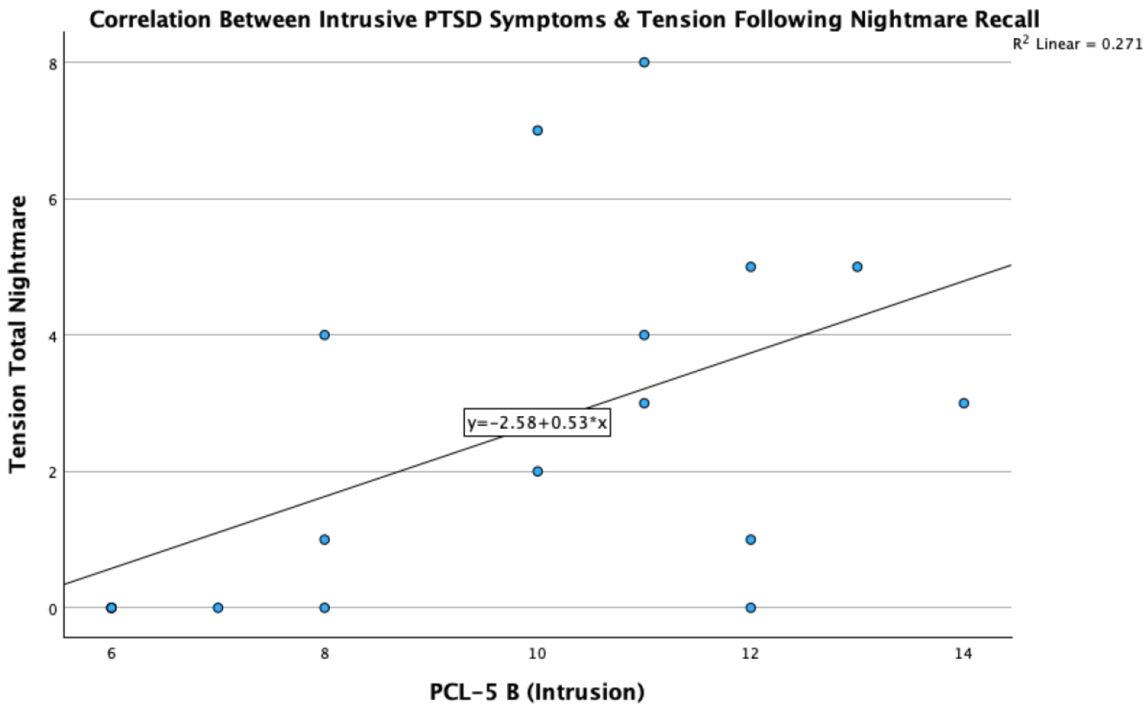
Intrusive PTSD symptoms were associated with Interoceptive experiences after recalling nightmares (r=0.718, p=0.001).

Figure 4. Correlation Between Intrusive PTSD Symptoms & Interoception Following Nightmare Recall.



Intrusion PCL-5 subscale was found to be positively associated with Tension somatic experiences after nightmare recall (r=0.556, p=0.021).

Figure 5. Correlation Between Intrusive PTSD Symptoms & Tension Following Nightmare Recall.



No other subscales (Hyperarousal, Avoidance, Negative Alterations in Cognition or Mood) were significantly correlated with any somatic experience.

LIWC WORD CATEGORIES

None of the LIWC Word Categories (Positive Emotion, Negative Emotion, Somatosensory) were significantly different between nightmare and trauma reports. From the output of the Spearman Correlation Matrix, LIWC Word Categories showed no association with PTSD symptom severity.

Study B. Personality Features of Trauma-Exposed Persons Reporting Trauma-Related Dreams

Two hierarchical regressions were conducted, each composed of three models: Model 1 consisting of demographic variables (Age, Sex, and Months from Trauma to Study); Model 2 including all factors of Model 1, with the addition of PCL-5 (either total or subscales); and Model 3 including all factors of Model 2, with the addition of a NEO PI-R domain. The first hierarchical regression test looked like the following:

Table 2. Hierarchical Regression Assessing Nightmare & Bad Dream Rate

Model 1: Age, Sex, Months from Trauma
Model 2: (Above) + Intrusion (without nightmare/sleep question) + Hyperarousal (without nightmare/sleep question)
Model 3: (Above) + Neuroticism (NEO PI-R N Domain)

Model Summary[d]

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.179[a]	.032	.008	17.8280280	.032	1.307	3	118	.275	
2	.327[b]	.107	.068	17.2748035	.075	4.839	2	116	.010	
3	.330[c]	.109	.062	17.3284698	.002	.283	1	115	.596	1.975

a. Predictors: (Constant), monthsfromtraumatostudy, Age, Sex
b. Predictors: (Constant), monthsfromtraumatostudy, Age, Sex, IntrusionwithoutNightmare, Hyperarousalwosleepquestion
c. Predictors: (Constant), monthsfromtraumatostudy, Age, Sex, IntrusionwithoutNightmare, Hyperarousalwosleepquestion, NEOPIRN
d. Dependent Variable: NightmareandBaddreamrate

The second hierarchical regression model consisted of the same model outline, however used the number of replicable nightmares as its outcome measure.

Hierarchical Regression Assessing Number of Replicable Nightmares
Model 1: Age, Sex, Months from Trauma
Model 2: (Above) + Intrusion (without nightmare/sleep question) + Hyperarousal (without nightmare/sleep question)
Model 3: (Above) + Neuroticism (NEO PI-R N Domain)

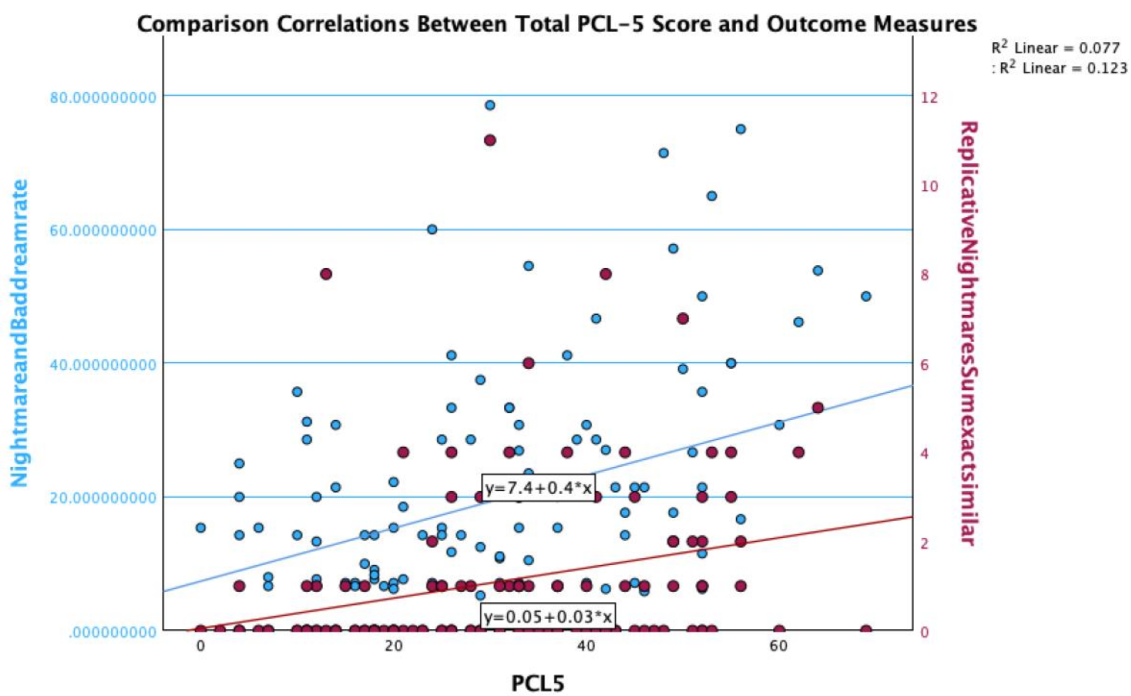
Statistical analysis of hierarchical regressions can be interpreted by the change in the F value. In the first hierarchical regression, testing the nightmare and bad dream rate, the change in F for the second model (p=0.010) represents that Model 2 (the addition of PCL-5 subscales intrusion and hyperarousal) significantly predicts the dependent variable (in this case the nightmare and bad dream rate) above and beyond Model 1. When looking at our variable of interest, neuroticism, and assessing whether it predicts the nightmare and bad dream rate or the number of replicable nightmares, we see that in both regressions that this is not significant (p=0.596; p=0.886). Neuroticism does not predict the nightmare and bad dream rate or the number of replicable nightmares above and beyond PTSD severity, when taking demographic factors into account. Exploring further, we ran different combinations of these models (total PCL-5, other subscales of PCL-5, hyperarousal, and intrusion subscales individually, other factors of the NEO PI-R, etc.), which had no significance for either outcome variable.

To further support our findings, we ran Pearson Correlation analyses to determine if there are any associations between neuroticism and any of our other predictor variables, nightmare and bad dream rate and number of replicable nightmares. This served as a method of detecting possible collinearity between neuroticism and PTSD severity. Collinearity, determined by a high correlation between these factors, could explain the lack of significance in the hierarchical regression analyses, as there would essentially be no difference between the second (PTSD severity) and third (neuroticism) models. Similarly, we additionally used correlation statistics to establish relationships between PTSD severity and both outcome variables.

PTSD SYMPTOM SEVERITY AND NIGHTMARES

Both nightmare and bad dream rate and the number of replicative nightmares were positively correlated with PTSD symptom severity. Nightmare and bad dream rate demonstrated a stronger association with PTSD severity (r=0.351, p<0.001) than did the number of replicative nightmares (r=0.281, p<0.001). The relationship between these two outcome variables and their association with PTSD symptom severity can be seen here:

Figure 6. Comparison Correlations Between Total PCL-5 Score and Outcome Measures.

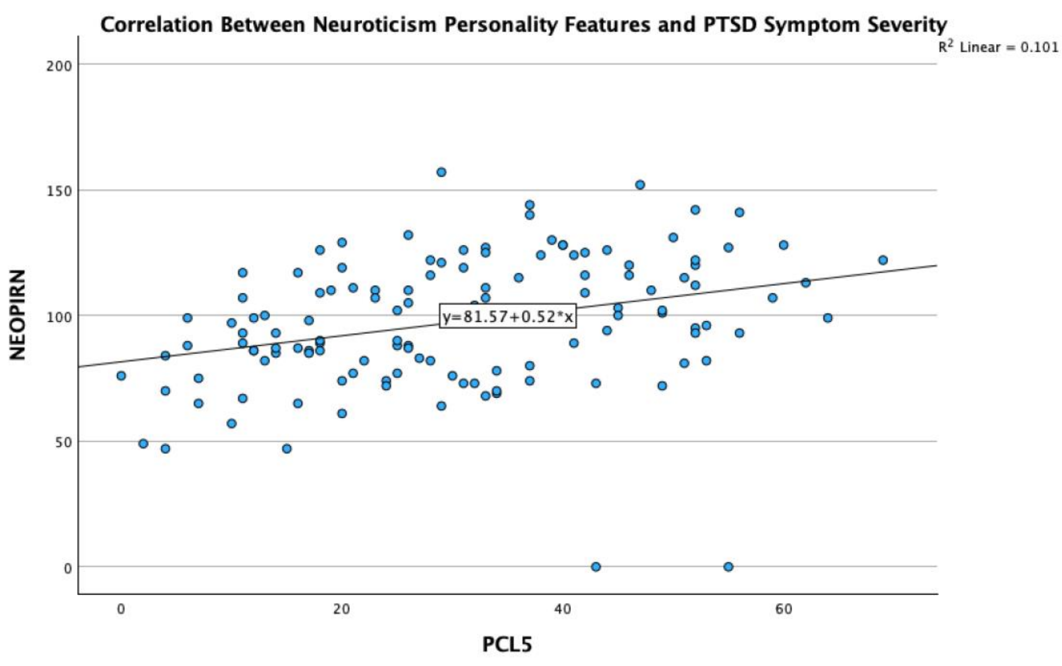


However, only certain subscales of the PCL-5 showed similar patterns as total PCL-5. For the intrusion symptom cluster of the PCL-5, nightmare and bad dream rate was significantly correlated with intrusion (r=0.267, p=0.003), however replicative nightmares were not (r=0.167, p=0.062). Nightmare and bad dream rate (r=0.232, *p*=0.010) and replicative nightmares (*r*=0.196, *p*=0.028) were positively correlated with hyperarousal. Avoidance was not significantly correlated with either outcome variable. The negative alterations in cognition or mood subscale of PTSD did demonstrate positive associations with both outcome measures (nightmare and bad dream rate: *r*=0.333, *p*<0.001; replicative nightmares: *r*=0.253, *p*=0.004).

PTSD SYMPTOM SEVERITY AND NEUROTICISM

Assessing possible collinearity between neuroticism personality features and PTSD symptom severity, Pearson correlation tests revealed a moderate positive relationship between these variables (*r*=0.317, *p*<0.001).

Figure 7. Correlation Between Neuroticism Personality Features and PTSD Symptom Severity.



This collinearity may explain why neuroticism did not predict nightmare and bad dream rate nor the number of replicative nightmares above and beyond PTSD, while accounting for demographic factors, in our hierarchical regression models.

Examining the different aspects of PTSD symptoms and their relation to neuroticism, all subscales showed positive correlations. Hyperarousal had the strongest relationship with neuroticism (r=0.362, p<0.001), followed by negative alterations in cognition and mood (r=0.268, p=0.002), intrusion (r=0.238, p=0.007), and finally avoidance (r=0.231, p=0.009).

DISCUSSION

To examine the possible relationships between somatic experiences, linguistic analysis, and neuroticism on trauma and nightmare states as well as with PTSD severity, this analysis was compartmentalized into two studies: the first comparing language and bodily sensations across trauma and nightmare conditions, and the second analyzing personality features of those who have experienced trauma and trauma-related nightmares.

Study A. Comparison of Language & Somatic Experiences Between Reports of Trauma and Trauma-Related Dreams

Study A. compared language and somatic experiences between reports of trauma and TRNs. Language was measured by the Linguistic Analysis and Word Count (LIWC) program, which uses categories of words to analyze a given text, generating a percentage of a specific word category found in the text. Somatic experiences were created through a document provided during study participation, prompting them to circle various bodily sensations they have experienced either after writing about their traumatic event or after recalling a nightmare related to their trauma. These bodily sensations were later grouped together into categories: tension, cardiovascular, respiratory, and interoception. Participants recalled a traumatic experience most related to their nightmares, through writing during an in-person visit with research staff. Nightmares were recalled through an audio recorder soon after participants awakened and were later transcripted by research staff into text scripts. Participants were administered the PTSD Checklist for DSM-5 (PCL-5) questionnaire to assess PTSD symptom severity. This questionnaire breaks down the PTSD diagnosis into its cluster symptoms: Cluster B (Intrusion), C (Avoidance), D (Negative Alterations in Cognition and Mood), and E (Hyperarousal). Since the intrusion and hyperarousal clusters included questions on sleep and nightmares, these specific items were removed from our intrusion and hyperarousal cluster variables.

H1: SOMATIC EXPERIENCES WILL BE STRONGER DURING TRAUMA RECALL.

We hypothesized that somatic experiences such as tension, interoception, cardiovascular, and respiratory bodily sensations would be stronger and more present after trauma than after nightmare recall. This reasoning is based on the neurobiology of sleep in that the brain undergoes "sensory gating," through the inhibitory acts of the reticular thalamic nucleus (RTN) on the thalamus to prevent sensory information from reaching the cerebral cortex (Coenen 2024; McCormick & Bal, 1994). Therefore, we predicted that recalling somatic experiences from a sleeping state would be more difficult and less present than when recalling a traumatic experience in a wakeful state.

Through statistical analysis using the Wilcoxon Signed-Rank Test, we found that only interoception and tension followed the predicted trend and were more present after trauma recall than nightmare recall. Cardiovascular and respiratory sensations did not differ across nightmare and trauma conditions.

H2: PTSD SYMPTOM SEVERITY WILL BE POSITIVELY ASSOCIATED WITH SOMATIC EXPERIENCES, ESPECIALLY AFTER TRAUMA RECALL.

Following the concept of sensory gating and the sensory deafferentation that occurs during sleeping states, we hypothesized that those with more severe PTSD symptoms will have more somatic experiences especially after trauma recall. We predict that those with more severe PTSD symptoms would show stronger somatosensory feelings, such as increases in heart rate and respiration rate.

Through Spearman Correlation Matrices, we found that PTSD severity as measured by the PCL-5 in itself was not significantly associated with somatic experiences in either trauma or nightmare conditions. However, when breaking up the PCL-5 and analyzing the relationships between somatic experiences with its individual clusters, we did find significant associations. The intrusion cluster of PTSD symptom severity was found to be positively correlated with cardiovascular and respiratory bodily sensations following traumatic event recall. This cluster was also positively correlated with interoception and tension bodily sensations following nightmare recall. None of the other PTSD symptom clusters (hyperarousal, avoidance, negative alterations in cognition or mood) were found to be associated with any of the somatic experiences (tension, interoception, cardiovascular, respiratory).

Interestingly, cardiovascular and respiratory were both positively correlated with intrusion symptoms after recalling traumatic experiences but did not overall differ across nightmare and trauma conditions from our first hypothesis. This finding suggests that PTSD symptom severity is needed to facilitate the difference of cardiovascular and respiratory sensations between trauma and nightmare recall.

H3: POSITIVE AND NEGATIVE EMOTION LIWC WORD CATEGORIES WILL NOT BE SIGNIFICANT ACROSS TRAUMA AND NIGHTMARE CONDITIONS & SOMATOSENSORY WORD CATEGORY WILL BE HIGHER DURING TRAUMA RECALL.

We predicted that the positive and negative word categories on the LIWC would not differ from trauma and nightmare conditions. This was based on the assumption that both nightmares and traumatic experiences elicit similar emotional responses and that nightmares are a common feature in those diagnosed with PTSD. We also predicted that the somatosensory word category that was combined from the three separate “visual,” “auditory,” and “feeling” categories by research staff would be significantly higher during trauma recall, based on sensory gating and sensory deafferentation concepts.

Through analysis with the Wilcoxon Signed-Rank Test we found, consistent with our hypothesis, both positive and negative emotion LIWC word categories did not show significant differences between nightmare and trauma reports. Though the somatosensory word category, too, did not show statistical significance which was not consistent with our predictions.

It’s possible that this discrepancy may be due to either the grouping of “visual,” “auditory,” and “feeling” categories not being fully representative of somatosensation, or that possibly linguistic analysis is not as accurate in detecting somatosensation differences than other measures such as self-reporting.

H4: NEGATIVE AND SOMATOSENSORY LIWC WORD CATEGORIES WILL BE POSITIVELY CORRELATED WITH PTSD SEVERITY.

We predicted that negative and somatosensory (“visual,” “auditory,” “feeling") word categories will be positively correlated with PTSD symptom severity. This prediction is based on the assumption that the more symptomatic one is, the more they would be emotionally vulnerable to recall traumatic and nightmare experiences, especially regarding negative emotions and somatosensation. Spearman Correlation Matrices showed no relationship between these LIWC word categories and PTSD symptom severity.

Although this result is not as expected, this could possibly be due to the previous pattern of total PTSD symptom severity showing no significance, until broken down into symptom clusters. It's possible that the potential relationships between negative emotion and somatosensory LIWC word categories and PTSD symptom severity might only be apparent for the intrusion cluster.

Study B. Personality Features of Trauma-Exposed Persons Reporting Trauma-Related Dreams

Study B. compared personality features of trauma-exposed participants reporting trauma-related dreams. Participants completed The Revised NEO Personality Inventory (NEO PI-R) which is a questionnaire measuring the standard conceptual model of personality: the Five Factor Model of Personality. The NEO PI-R assesses emotional, interpersonal, attitudinal, and motivational styles and categorizes these findings into the five dimensions of personality: agreeableness, conscientiousness, openness to experience, extraversion, and neuroticism. Participants completed the PCL-5 and the Evening/Morning Sleep Questionnaire (EMSQ) and categorized their dreams into multiple categories, most relevantly "nightmares," defined as a very disturbing dream that results in one waking up while the dream is happening and "bad dreams," defined as a very disturbing or unpleasant dream that did not result in an awakening. These two categories were then combined and divided by the number of nights reported to become one of our outcome measures, “nightmare and bad dream rate.” Participants were additionally asked to rate how similar their nightmares were to their recent traumatic experience based on a likert scale. The two highest rankings (“exactly or almost exactly like the traumatic event” and “similar to the traumatic event”) were summed and termed our second outcome measure, “replicative nightmares,” representing a numerical count across all of the nights reported rather than a rate.

H5: NEUROTICISM PERSONALITY FEATURES WILL ADD A SIGNIFICANT EXPLANATION OF VARIANCE IN BOTH NIGHTMARE AND BAD DREAM RATE AND NUMBER OF REPLICATIVE NIGHTMARES, EVEN WHEN CONTROLLING FOR PTSD SEVERITY AND DEMOGRAPHIC FACTORS.

Due to the known and established relationship between neurotic personality features and PTSD, we predicted that neuroticism would significantly explain the variance in both nightmare and bad dream rate and the number of replicative nightmares, even when controlling for PTSD severity and demographic factors. This analysis was conducted because if PTSD severity was not controlled for, it may be the PTSD severity that is impeding the relationship of interest: neuroticism with nightmare and bad dream rate and number of replicative nightmares.

To assess this possible relationship, we used hierarchical regression models. We found that neuroticism did not predict neither nightmare and bad dream rate nor the number of replicative nightmares above and beyond PTSD severity, when taking demographic factors into account. Even when exploring separating the PTSD symptom clusters and using them rather than the total PCL-5 score and using other personality factors from the NEO PI-R, there still was a lack of significance.

This lack of significance could be explained by possible collinearity between these factors, as there would essentially be no difference between the second (PTSD severity) and third (neuroticism) models, due to the high correlational relationship between the two. To determine if this was the case, we used Pearson Correlations for neuroticism and PTSD severity with both outcome variables.

We found that both of our outcome variables were positively correlated with PTSD symptom severity, with nightmare and bad dream rate having a stronger relationship than the number of replicative nightmares. Only nightmare and bad dream rate was significantly correlated with the intrusion cluster, and both nightmare and bad dream rate and number of replicative nightmares were significantly correlated with the hyperarousal cluster. The avoidance cluster did not show significant relationships with either variable, however the negative alterations in cognition or mood cluster did have significant correlations with both outcome measures.

Assessing possible collinearity, we did find a moderate positive relationship between neuroticism and PTSD symptom severity, which could explain the lack of significance found in the hierarchical regression models–or why neuroticism did not predict nightmare and bad dream rate nor the number of replicative nightmares above and beyond PTSD, while accounting for demographic factors. Neuroticism was positively correlated with all subscales of PTSD, most strongly with the hyperarousal cluster.

LIMITATIONS

This study was met with various limitations that could affect the significance found bidirectionally. Firstly, both studies had a limited sample size with only 17 and 126 participants for Study A and B, respectively. Secondly, many decisions were made at the discretion of research staff that could affect the results found. One of these decisions include the many variable combinations made (somatosensory in the LIWC, all the somatic sensations from the check-list document that participants completed that were combined into 4 somatic sensation variables, replicative nightmares, and nightmare and bad dream rate variables). Staff additionally edited the raw nightmare scripts produced by direct audio transcription, to remove any contextual details that were not specific to the true nightmare experience, which was solely based on staff's discretion.

In addition to being small, our samples were also predominantly White (82.4% and 64.3%) and female (76.5% and 69%). A more diverse sample could point to trends in how various individuals describe their nightmare and traumatic experiences.

FUTURE DIRECTIONS

This study is the first to directly compare linguistic analysis between reports of trauma and trauma-related nightmares in those with PTSD, and even broad data comparing between nightmare and traumatic experiences in PTSD is limited. As Artificial Intelligence improves, there will surely be advancements in language processing tools beyond the LIWC that was used in this study. Sensory gating and sensory deafferentation are phenomena that have only been briefly studied with respect to tension and interoceptive somatic sensations. The neurobiology of nightmares specifically, not just the neurobiology of REM sleep, should be analyzed deeper to understand whether sensory gating and deafferentation are involved. Gaining deeper understandings of nightmares and trauma in those with PTSD can allow for new discoveries for treatment, such as through targeting fear extinction processes

REFERENCES

Alpers, G. W., Winzelberg, A. J., Classen, C., Roberts, H., Dev, P., Koopman, C., & Barr Taylor, C. (2005, March). Evaluation of computerized text analysis in an Internet breast cancer support group. *Computers in Human Behavior*, *21*(2), 361–376. https://doi.org/10.1016/j.chb.2004.02.008

Atwoli, L., Stein, D. J., Koenen, K. C., & McLaughlin, K. A. (2015). Epidemiology of Posttraumatic Stress Disorder. *Current Opinion in Psychiatry*, *28*(4), 307–311. https://doi.org/10.1097/yco.0000000000000167

Bantum, E. O., & Owen, J. E. (2009, March). Evaluating the validity of computerized content analysis programs for identification of emotional expression in cancer narratives. *Psychological Assessment*, *21*(1), 79–88. https://doi.org/10.1037/a0014643

Barkay, G., Freedman, N., Lester, H., Louzoun, Y., Sapoznikov, D., Luckenbaugh, D., Shalev, A. Y., Chisin, R. G., & Bonne, O. (2012, November). Brain activation and heart rate during script-driven traumatic imagery in PTSD: Preliminary findings. *Psychiatry Research: Neuroimaging*, *204*(2–3), 155–160. https://doi.org/10.1016/j.pscychresns.2012.08.007

Benjet, C., Bromet, E., Karam, E. G., Kessler, R. C., McLaughlin, K. A., Ruscio, A. M., Shahly, V., Stein, D. J., Petukhova, M., Hill, E., Alonso, J., Atwoli, L., Bunting, B., Bruffaerts, R., Caldas-de-Almeida, J. M., de Girolamo, G., Florescu, S., Gureje, O., Huang, Y., … Koenen, K. C. (2015). The epidemiology of traumatic event exposure worldwide: Results from the World Mental Health Survey Consortium. *Psychological Medicine*, *46*(2), 327–343. https://doi.org/10.1017/s0033291715001981

Blumberg, M. S., Lesku, J. A., Libourel, P.-A., Schmidt, M. H., & Rattenborg, N. C. (2020). What is REM sleep? *Current Biology*, *30*(1). https://doi.org/10.1016/j.cub.2019.11.045

Bulkeley, K., & Graves, M. (2018, March). Using the LIWC program to study dreams. *Dreaming*, *28*(1), 43–58. https://doi.org/10.1037/drm0000071

Bujarski, S. J., Mischel, E., Dutton, C., Steele, J. S., & Cisler, J. (2015). The Elicitation and Assessment of Emotional Responding. *Sleep and Affect*, 91–118. https://doi.org/10.1016/b978-0-12-417188-6.00005-0

Campbell, R. L., & Germain, A. (2016). Nightmares and posttraumatic stress disorder (PTSD). *Current Sleep Medicine Reports*, *2*(2), 74–80. https://doi.org/10.1007/s40675-016-0037-0

Chokroverty, S. (Ed.). (2017). *Sleep Disorders Medicine*. https://doi.org/10.1007/978-1-4939-6578-6

Chung, C. K., & Pennebaker, J. W. (n.d.). What Do We Know When We LIWC a Person? Text Analysis as an Assessment Tool for Traits, Personal Concerns and Life Stories. *The SAGE Handbook of Personality and Individual Differences: Volume I: The Science of Personality and Individual Differences*, 341–360. https://doi.org/10.4135/9781526451163.n16

Coenen, A. (2024, January 29). Sensory gating and gaining in sleep: the balance between the protection of sleep and the safeness of life (a review). *Journal of Sleep Research*. https://doi.org/10.1111/jsr.14152

Coenen, A. (2015). Synaptic strength expressed in EPSP size is downscaled in sleep: evidence for the synaptic homeostasis hypothesis. *SLEEP-WAKE*.

Coenen, A., & Drinkenburg, W. (2002, December). Animal models for information processing during sleep. *International Journal of Psychophysiology*, *46*(3), 163–175. https://doi.org/10.1016/s0167-8760(02)00110-1

Coenen, A. M. L., & Vendrik, A. J. H. (1972). Determination of the transfer ratio of cat's geniculate neurons through quasi-intracellular recordings and the relation with the level of alertness. *Experimental Brain Research*, *14*(3), 227–242. https://doi.org/10.1007/bf00816160

Contractor, A. A., Armour, C., Shea, M. T., Mota, N., & Pietrzak, R. H. (2016, January). Latent profiles of DSM-5 PTSD symptoms and the "Big Five" personality traits. *Journal of Anxiety Disorders*, *37*, 10–20. https://doi.org/10.1016/j.janxdis.2015.10.005

Corsi-Cabrera, M., Velasco, F., del Río-Portilla, Y., Armony, J. L., Trejo-Martínez, D., Guevara, M. A., & Velasco, A. L. (2016, May 5). Human amygdala activation during rapid eye movements of rapid eye movement sleep: an intracranial study. *Journal of Sleep Research*, *25*(5), 576–582. https://doi.org/10.1111/jsr.12415

Cox, B. J., MacPherson, P. S., Enns, M. W., & McWilliams, L. A. (2004, January). Neuroticism and self-criticism associated with posttraumatic stress disorder in a nationally representative sample. *Behaviour Research and Therapy*, *42*(1), 105–114. https://doi.org/10.1016/s0005-7967(03)00105-0

Dement, W., & Wolpert, E. A. (1958). The relation of eye movements, body motility, and external stimuli to dream content. *Journal of Experimental Psychology*, *55*(6), 543–553. https://doi.org/10.1037/h0040031

Douglas, N. J., White, D. P., Pickett, C. K., Weil, J. V., & Zwillich, C. W. (1982, November 1). Respiration during sleep in normal man. *Thorax*, *37*(11), 840–844. https://doi.org/10.1136/thx.37.11.840

Drake, M. E., Pakalnis, A., Andrews, J. M., & Bogner, J. E. (1990, September). Nocturnal Sleep Recording with Cassette EEG in Chronic Headaches. *Headache: The Journal of Head and Face Pain*, *30*(9), 600–603. https://doi.org/10.1111/j.1526-4610.1990.hed3009600.x

FAUERBACH, J. A., LAWRENCE, J. W., SCHMIDT, C. W., MUNSTER, A. M., & COSTA, P. T. (2000, August). Personality Predictors of Injury-Related Posttraumatic Stress Disorder. *The Journal of Nervous and Mental Disease*, *188*(8), 510–517. https://doi.org/10.1097/00005053-200008000-00006

Germain, A., Buysse, D. J., & Nofzinger, E. (2008, June). Sleep-specific mechanisms underlying posttraumatic stress disorder: Integrative review and neurobiological hypotheses. *Sleep Medicine Reviews*, *12*(3), 185–195. https://doi.org/10.1016/j.smrv.2007.09.003

Guzick, A. G., Tendler, A., Brown, L. A., Onyeka, O. C., & Storch, E. A. (2024, January 30). Linguistic and affective characteristics of script-driven imagery for adults with posttraumatic stress order: Associations with clinical outcomes during deep transcranial magnetic stimulation. *Journal of Traumatic Stress*. https://doi.org/10.1002/jts.23010

Harvard Medical School, 2007. National Comorbidity Survey (NCS). (2017, August 21). Retrieved from https://www.hcp.med.harvard.edu/ncs/index.php. Data Table 2: 12-month prevalence DSM-IV/WMH-CIDI disorders by sex and cohort.

Hawkins, R. C., & Boyd, R. L. (2017, June). Such stuff as dreams are made on: Dream language, LIWC norms, and personality correlates. *Dreaming*, *27*(2), 102–121. https://doi.org/10.1037/drm0000049

Hennevin, E., Huetz, C., & Edeline, J. M. (2007). Neural representations during sleep: from sensory processing to memory traces. *Neurobiology of learning and memory*, *87*(3), 416–440. https://doi.org/10.1016/j.nlm.2006.10.006

Hopper, J. W., Frewen, P. A., Sack, M., Lanius, R. A., & van der Kolk, B. A. (2007). The responses to script-driven imagery scale (RSDI): Assessment of state posttraumatic symptoms for psychobiological and treatment research. *Journal of Psychopathology and Behavioral Assessment*, *29*(4), 249–268. https://doi.org/10.1007/s10862-007-9046-0

Kahn, J. H., Tobin, R. M., Massey, A. E., & Anderson, J. A. (2007, July 1). Measuring Emotional Expression with the Linguistic Inquiry and Word Count. *The American Journal of Psychology*, *120*(2), 263–286. https://doi.org/10.2307/20445398

Kernberg, O. F. (2016, April). What Is Personality? *Journal of Personality Disorders*, *30*(2), 145–156. https://doi.org/10.1521/pedi.2106.30.2.145

Kessler, R. C., Aguilar-Gaxiola, S., Alonso, J., Benjet, C., Bromet, E. J., Cardoso, G., Degenhardt, L., de Girolamo, G., Dinolova, R. V., Ferry, F., Florescu, S., Gureje, O., Haro, J. M., Huang, Y., Karam, E. G., Kawakami, N., Lee, S., Lepine, J.-P., Levinson, D., … Koenen, K. C. (2017). Trauma and PTSD in the WHO world mental health surveys. *European Journal of Psychotraumatology*, *8*(sup5). https://doi.org/10.1080/20008198.2017.1353383

Kilpatrick, K. L., & Williams, L. M. (1998). Potential mediators of post-traumatic stress disorder in child witnesses to domestic violence. *Child Abuse & Neglect*, *22*(4), 319–330. https://doi.org/10.1016/s0145-2134(97)00178-6

Köthe, M., & Pietrowsky, R. (2001, March). Behavioral effects of nightmares and their correlations to personality patterns. *Dreaming*, *11*(1), 43–52. https://doi.org/10.1023/a:1009468517557

Krakow, B., Schrader, R., Tandberg, D., Hollifield, M., Koss, M. P., Yau, C. L., & Cheng, D. T. (2002). Nightmare frequency in sexual assault survivors with PTSD. *Journal of Anxiety Disorders*, *16*(2), 175–190. https://doi.org/10.1016/s0887-6185(02)00093-2

Kryger, M. H., Roth, T., & Dement, W. C. (2010). *Principles and Practice of Sleep Medicine E-Book: Expert Consult-Online and Print*. Elsevier Health Sciences.

Lancaster, C., Teeters, J., Gros, D., & Back, S. (2016). Posttraumatic stress disorder: Overview of evidence-based assessment and treatment. *Journal of Clinical Medicine*, *5*(11), 105. https://doi.org/10.3390/jcm5110105

Lang, R. J., & O'Connor, K. P. (1984, January). Personality, dream content and dream coping style. *Personality and Individual Differences*, *5*(2), 211–219. https://doi.org/10.1016/0191-8869(84)90053-9

Lawton, E. M., Shields, A. J., & Oltmanns, T. F. (2011). Five-factor model personality disorder prototypes in a community sample: Self- and informant-reports predicting interview-based DSM diagnoses. *Personality Disorders: Theory, Research, and Treatment*, *2*(4), 279–292. https://doi.org/10.1037/a0022617

Li, D., Zhang, W., Li, X., Zhen, S., & Wang, Y. (2010, September). Stressful life events and problematic Internet use by adolescent females and males: A mediated moderation model. *Computers in Human Behavior*, *26*(5), 1199–1207. https://doi.org/10.1016/j.chb.2010.03.031

Marek, R., Strobel, C., Bredy, T. W., & Sah, P. (2013, April 9). The amygdala and medial prefrontal cortex: partners in the fear circuit. *The Journal of Physiology*, *591*(10), 2381–2391. https://doi.org/10.1113/jphysiol.2012.248575

McCormick, D. A., & Bal, T. (1994, August). Sensory gating mechanisms of the thalamus. *Current Opinion in Neurobiology*, *4*(4), 550–556. https://doi.org/10.1016/0959-4388(94)90056-6

McCrae, R. R., & John, O. P. (1992, June). An Introduction to the Five-Factor Model and Its Applications. *Journal of Personality*, *60*(2), 175–215. https://doi.org/10.1111/j.1467-6494.1992.tb00970.x

McGrory, C. M., Mendelsohn, A. K., Pineles, S. L., Lasko, N. B., Ivkovic, V., Moon, M., Cetinkaya, D., Bazer, O., Fortier, E., Kelly, A., Bragdon, L. B., Tanev, K., Orr, S. P., Pace-Schott, E. F. (2023). Comparison of Autonomic Reactivity to Trauma and Nightmare Imagery. [Preprint].

Mendelsohn, A. K., Orr, S., Ivkovic, V., Fortier, E., Kelly, A., Cetinkaya, D., Martinez, U., Bazer, O., Tanev, K., Lasko, N., Pineles, S., & Pace-Schott, E. (2022, May 25). 0673 Script-Driven Imagery in PTSD: Comparing Reactivity to Imagery of Trauma Memories to Imagery of Trauma-Nightmare Memories. *Sleep*, *45*(Supplement_1), A295–A295. https://doi.org/10.1093/sleep/zsac079.669

Mezzanotte, W. S., Tangel, D. J., & White, D. P. (1996, June). Influence of sleep onset on upper-airway muscle activity in apnea patients versus normal controls. *American Journal of Respiratory and Critical Care Medicine*, *153*(6), 1880–1887. https://doi.org/10.1164/ajrccm.153.6.8665050

Muir, K., Madill, A., & Brown, C. (2022, February 14). Reflective rumination mediates the effects of neuroticism upon the fading affect bias in autobiographical memory. *Self and Identity*, *22*(1), 102–128. https://doi.org/10.1080/15298868.2022.2041080

Murray Sherman, S. (2001). Chapter 4 Thalamic relay functions. *Progress in Brain Research*, 51–69. https://doi.org/10.1016/s0079-6123(01)34005-0

Myers, K. M., Ressler, K. J., & Davis, M. (2006, March). Different mechanisms of fear extinction dependent on length of time since fear acquisition. *Learning & Memory*, *13*(2), 216–223. https://doi.org/10.1101/lm.119806

Nardo, D., Högberg, G., Jonsson, C., Jacobsson, H., Hällström, T., & Pagani, M. (2015, September 28). Neurobiology of Sleep Disturbances in PTSD Patients and Traumatized Controls: MRI and SPECT Findings. *Frontiers in Psychiatry*, *6*. https://doi.org/10.3389/fpsyt.2015.00134

Nielsen, T., & Levin, R. (2007, August). Nightmares: A new neurocognitive model. *Sleep Medicine Reviews*, *11*(4), 295–310. https://doi.org/10.1016/j.smrv.2007.03.004

Norrholm, S. D., Jovanovic, T., Olin, I. W., Sands, L. A., Karapanou, I., Bradley, B., & Ressler, K. J. (2011, March). Fear Extinction in Traumatized Civilians with Posttraumatic Stress Disorder: Relation to Symptom Severity. *Biological Psychiatry*, *69*(6), 556–563. https://doi.org/10.1016/j.biopsych.2010.09.013

Ogle, C. M., Rubin, D. C., & Siegler, I. C. (2015, June 24). Accounting for Posttraumatic Stress Disorder Symptom Severity With Pre- and Post Trauma Measures. *Clinical Psychological Science*, *4*(2), 272–286. https://doi.org/10.1177/2167702615583227

Orem, J., Lovering, A. T., Dunin-Barkowski, W., & Vidruk, E. H. (2000, September). Endogenous excitatory drive to the respiratory system in rapid eye movement sleep in cats. *The Journal of Physiology*, *527*(2), 365–376. https://doi.org/10.1111/j.1469-7793.2000.00365.x

Oswald, I., Taylor, A. M., & Treisman, M. (1960). Discriminative Responses To Stimulation During Human Sleep. *Brain*, *83*(3), 440–453. https://doi.org/10.1093/brain/83.3.440

Owen, J. E., Giese-Davis, J., Cordova, M., Kronenwetter, C., Golant, M., & Spiegel, D. (2006, July 15). Self-Report and Linguistic Indicators of Emotional Expression in Narratives as Predictors of Adjustment to Cancer. *Journal of Behavioral Medicine*, *29*(4), 335–345. https://doi.org/10.1007/s10865-006-9061-8

Pace-Schott, E. F. (2023). Comparison of Autonomic Reactivity to Trauma and Nightmare Imagery. [Preprint].

Pace-Schott, E. F., Amole, M. C., Aue, T., Balconi, M., Bylsma, L. M., Critchley, H., Demaree, H. A., Friedman, B. H., Gooding, A. E. K., Gosseries, O., Jovanovic, T., Kirby, L. A., Kozlowska, K., Laureys, S., Lowe, L., Magee, K., Marin, M. F., Merner, A. R., Robinson, J. L., . . . VanElzakker, M. B. (2019, August). Physiological feelings. *Neuroscience & Biobehavioral Reviews*, *103*, 267–304. https://doi.org/10.1016/j.neubiorev.2019.05.002

Pennebaker, J. W., & Francis, M. E. (1999). Linguistic Inquiry and Word Count (LIWC). Erlbaum Publishers.

Perrin, F. (1999, December 1). A differential brain response to the subject’s own name persists during sleep. *Clinical Neurophysiology*, *110*(12), 2153–2164. https://doi.org/10.1016/s1388-2457(99)00177-7

PETERS, L., ISSAKIDIS, C., SLADE, T., & ANDREWS, G. (2005). Gender differences in the prevalence of DSM-IV and ICD-10 PTSD. *Psychological Medicine*, *36*(1), 81–89. doi:10.1017/S003329170500591X

Quigley, K. S., Kanoski, S., Grill, W. M., Barrett, L. F., & Tsakiris, M. (2021, January). Functions of Interoception: From Energy Regulation to Experience of the Self. *Trends in Neurosciences*, *44*(1), 29–38. https://doi.org/10.1016/j.tins.2020.09.008

Rains, J. C., Davis, R. E., & Smitherman, T. A. (2014, December 5). Tension-Type Headache and Sleep. *Current Neurology and Neuroscience Reports*, *15*(2). https://doi.org/10.1007/s11910-014-0520-2

Ruch, S., Alain Züst, M., & Henke, K. (2022, January). Sleep-learning impairs subsequent awake-learning. *Neurobiology of Learning and Memory*, *187*, 107569. https://doi.org/10.1016/j.nlm.2021.107569

Sauvageau, A., Nielsen, T. A., & Montplaisir, J. (1998, June). Effects of somatosensory stimulation on dream content in gymnasts and control participants: Evidence of vestibulomotor adaptation in REM sleep. *Dreaming*, *8*(2), 125–134. https://doi.org/10.1023/b:drem.0000005902.04938.fe

Schäfer, T., & Schläfke, M. E. (1998, December 1). Respiratory changes associated with rapid eye movements in normo- and hypercapnia during sleep. *Journal of Applied Physiology*, *85*(6), 2213–2219. https://doi.org/10.1152/jappl.1998.85.6.2213

Schaefer Ziemer, K., & Korkmaz, G. (2016, July 10). Human vs. Automated Text Analysis. *Proceedings of the 27th ACM Conference on Hypertext and Social Media*. https://doi.org/10.1145/2914586.2914634

Schredl, M., & Goeritz, A. S. (2019, September). Nightmare frequency and nightmare distress: Socio-demographic and personality factors. *Sleep Science*, *12*(03), 178–184. https://doi.org/10.5935/1984-0063.20190080

Schredl, M., & Göritz, A. S. (2020, March). Reading dream literature and the Big Five personality factors. *Dreaming*, *30*(1), 45–53. https://doi.org/10.1037/drm0000129

Seravalle, G., Mancia, G., & Grassi, G. (2018, July 6). Sympathetic Nervous System, Sleep, and Hypertension. *Current Hypertension Reports*, *20*(9). https://doi.org/10.1007/s11906-018-0874-y

Sherrington, C. S. (1911). *The integrative action of the nervous system*. https://doi.org/10.1037/13798-000

Silvani, A., & Dampney, R. A. L. (2013, December 15). Central control of cardiovascular function during sleep. *American Journal of Physiology-Heart and Circulatory Physiology*, *305*(12), H1683–H1692. https://doi.org/10.1152/ajpheart.00554.2013

Simos, A., & Berle, D. (2023). The phenomenology of nightmares in post-traumatic stress disorder and complex post-traumatic stress disorder. *European Journal of Trauma & Dissociation*, *7*(3), 100335. https://doi.org/10.1016/j.ejtd.2023.100335

Solms, M. (2011). Neurobiology and the neurological basis of dreaming. *Handbook of Clinical Neurology*, 519–544. https://doi.org/10.1016/b978-0-444-52006-7.00034-4

Soto, C. J., & Jackson, J. J. (2020, January). Five-Factor Model of Personality. *Psychology*. https://doi.org/10.1093/obo/9780199828340-0120

Torrico, T. J., & Munakomi, S. (2023). Neuroanatomy, Thalamus. In *StatPearls*. StatPearls Publishing.

Tov, W., Ng, K. L., Lin, H., & Qiu, L. (2013, December). Detecting well-being via computerized content analysis of brief diary entries. *Psychological Assessment*, *25*(4), 1069–1078. https://doi.org/10.1037/a0033007

Tsoukatos, J., Kiss, Z. H. T., Davis, K. D., Tasker, R. R., & Dostrovsky, J. O. (1997, February). Patterns of neuronal firing in the human lateral thalamus during sleep and wakefulness. *Experimental Brain Research*, *113*(2), 273–282. https://doi.org/10.1007/bf02450325

Tupes, E.C. and Christal, R.E. (1961) Recurrent Personality Factors based on Trait Ratings.USAF ASD Tech. Rep. No. 61-97, Lackland Airforce Base, TX: US Air Force.

Van Cauter, E., Polonsky, K. S., & Scheen, A. J. (1997, October 1). Roles of Circadian Rhythmicity and Sleep in Human Glucose Regulation*. *Endocrine Reviews*, *18*(5), 716–738. https://doi.org/10.1210/edrv.18.5.0317

Wakschal, E., Boland, E., Gehrman, P., & Haynes, P. (2018). 0935 the role of PTSD and major depressive symptoms in nightmare frequency and distress. *Sleep*, *41*(suppl_1). https://doi.org/10.1093/sleep/zsy061.934

WIDIGER, T. A. (2011, June). Personality and psychopathology. *World Psychiatry*, *10*(2), 103–106. https://doi.org/10.1002/j.2051-5545.2011.tb00024.x

Yin, Q., Wu, L., Yu, X., & Liu, W. (2019, September 20). Neuroticism Predicts a Long-Term PTSD After Earthquake Trauma: The Moderating Effects of Personality. *Frontiers in Psychiatry*, *10*. https://doi.org/10.3389/fpsyt.2019.00657

Ziemer, K. S., & Korkmaz, G. (2017, November). Using text to predict psychological and physical health: A comparison of human raters and computerized text analysis. *Computers in Human Behavior*, *76*, 122–127. https://doi.org/10.1016/j.chb.2017.06.038

Züst, M. A., Ruch, S., Wiest, R., & Henke, K. (2019, February). Implicit Vocabulary Learning during Sleep Is Bound to Slow-Wave Peaks. *Current Biology*, *29*(4), 541-553.e7. https://doi.org/10.1016/j.cub.2018.12.038

CURRICULUM VITAE

[redacted]

[redacted]

[redacted]

[redacted]