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Working Memory Capacity Among College Students: The Role of Gender and Posttraumatic Stress Symptoms

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WORKING MEMORY CAPACITY AMONG COLLEGE STUDENTS: THE ROLE OF GENDER AND POSTTRAUMATIC STRESS SYMPTOMS

by

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(Under the Direction of C. Thresa Yancey)

ABSTRACT

Among college students, 81.8% report experiencing at least one traumatic event in their lifetime, and approximately one third report experiencing Posttraumatic Stress Symptoms (PTSS) (Overstreet, Berenz, Kendler, Dick, & Amstadter, 2017). Individuals who experience PTSS may have impaired cognitive functioning when processing trauma-relevant material (Blanchette, Rutembesa, Habimana, & Caparos, 2018). An example of this is working memory capacity (WMC), which can be disrupted by affective distractors (Vytal, Cornwell, & Letkiewicz, 2013). In addition to impaired daily functioning (American Psychiatric Association (APA), 2013) those with lower cognitive performance also respond less effectively to clinical treatment options for PTSS (Wild & Gur, 2008). Furthermore, gender differences in PTSD prevalence (APA, 2013) and WMC (Maylor et al., 2007; Voyer et al., 1995) are well established. Conversely, little research is available on how PTSS influences an individual’s working memory capacity, specifically in the areas of verbal and numeric recall. The objective of the current study was to examine the role of gender as a potential moderator between PTSS and WMC, specifically verbal and numeric recall. Participants were 254 undergraduate students at a mid-sized southeastern university, recruited for an online study. Participants completed a self-report assessment of PTSS, two WMC tasks, and provided demographic information. Results confirmed a gender difference in PTSS, where women reported higher PTSS scores. There were no significant findings regarding gender and WMC (verbal and numeric recall). Similarly, there were nonsignificant findings for the relationship between PTSS and WMC. There was also a nonsignificant interaction effect. These results suggest that PTSS and gender do not affect WMC in the areas of verbal and numeric recall. However, there were significant methodological and environmental limitations associated with the study, minimizing the likelihood of detecting significant findings. The implications of the study are discussed, and future recommendations are provided.

INDEX WORDS: Posttraumatic stress symptoms, Gender differences, Working memory capacity, Executive function, Emotion, Verbal recall, Numeric recall

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DEDICATION

I dedicate this work to my parents, Ken and Alisa Bickham, for their continuous love and support during the challenges of graduate school and throughout life. Thank you for always encouraging me to ask questions and seek answers. I love you both.

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CHAPTER 1

INTRODUCTION

Trauma can be defined as the state of disruption caused by stressors severe enough to threaten life or make an individual believe they are in danger (Van der Kolk, 2014). Trauma is caused by several factors and, although the type of trauma may differ from one individual to another, research shows traumatic stressors can have harmful and long-lasting effects on an individual's well-being (Figley, 2012; Pearlin, 1989).

Trauma exposure and biological reactions often go hand in hand (Delahanty & Nugent, 2006). Researchers using functional magnetic resonance imaging (fMRI) techniques have studied brain regions associated with traumatic responses (Carter, Aldridge, Page, & Parker, 2014). Most attention has been paid to structural and functional changes in the hippocampus, amygdala, and medial prefrontal cortex (mPFC), largely due to the involvement of these areas in stress regulation and memory (Carter et al., 2014). The body responds to stress to adapt to the threat and help the body return to homeostasis; however, severe stress directly influences the system's functionality, and may lead to stress-related symptoms (American Psychiatric Association, 2013; Van der Kolk, 2014).

The most prevalent adverse consequence of trauma is posttraumatic stress symptoms (PTSS; American Psychiatric Association (APA), 2013). PTSS reflect an abnormal biological and psychological response to stress (Van der Kolk, 2014). The repetitive memories of the traumatic event, for example, can feel like re-exposure to the trauma, and lead to similar biological responses as those occurring at the time the trauma happened (APA, 2013; Carter et al., 2014; Delahanty & Nugent, 2006). The physiological response to fear, which is normal in situations of real danger, becomes generalized to harmless situations in individuals with PTSS

(APA, 2013). Individuals' bodies become hyper-alert and over respond in situations they previously perceived as safe (APA, 2013). If symptoms are severe and long-lasting, individuals may develop posttraumatic stress disorder (PTSD; APA, 2013).

The hippocampus is integral for learning, memory, and information processing (Carter et al., 2014). However, new research shows links between PTSD, the hippocampus, and cognitive deficiencies (Blanchette, Rutembesa, Habimana, & Caparos, 2018; Van der Kolk, 2014). PTSD is linked to impaired learning and memory functioning (Blanchette et al., 2018). Wild and Gur (2008) also discovered lower cognitive functioning affects response to standard psychological treatment for PTSD, finding that individuals with PTSD and poor memory functioning typically do not respond as well to psychological treatment for PTSD compared to individuals with PTSD who show normal memory functioning.

Furthermore, literature shows differences between men and women's working memory abilities (Meyer et al., 2018). However, relatively little research is available on how PTSS influences an individual's working memory capacity, specifically in the areas of verbal and numeric recall. Additionally, while a correlation exists between cognitive functioning and PTSD such that greater PTSD symptoms are correlated with a decline in cognitive functioning (Blanchette et al., 2018), studies investigating cognitive functioning and PTSD are limited. Sumner and colleagues (2017) found that although the causes of cognitive decline are frequently studied among older adults or military personnel, research is lacking among women and younger-aged samples. Lastly, studies also report gender differences in the experience of trauma and PTSS (Gavranidou, & Rosner, 2003; Kessler, Sonnega, Bromet, Highes, & Nelson, 1995). Specifically, research reveals that even though men are exposed to more traumatic events, women are twice as likely to develop PTSD (APA, 2013; Kessler et al., 1995).

Purpose of the Study

The goal of the current study was to extend research by exploring the impact posttraumatic stress symptoms have on undergraduate students' working memory capacity. Specifically, the role of gender on posttraumatic stress symptoms and working memory tasks was explored. Furthermore, the study aimed to examine if trauma-relevant content impacted how undergraduates performed on specific working memory tasks. Lastly, the study aimed to provide a larger theoretical and empirical context to explain the conditions by which posttraumatic stress symptoms affect working memory task performance.

In the current study the following questions were explored:

a) Do posttraumatic stress symptoms decrease working memory capacity in college students?
b) Is gender correlated with performance on working memory tasks? Specifically, when examining verbal and numeric recall.
c) Does gender moderate the relationship between posttraumatic symptoms and working memory task performance?

Memory

According to Atkinson (2013), the success of an individual in any avenue of life largely depends on their memory. Within psychology, memory is often defined as the portion of the brain where information is encoded, stored, and retrieved when it is called upon (Atkinson, 2013; Carter et al., 2014). Memory can be delineated as long-term or short-term. Whereas short-term memory, or working memory, has a limited capacity and duration to store information, long-term memory can store a large amount of information for a potentially unlimited amount of time (Dalgleish & Power, 1999). While the brain works efficiently to process, store, and retrieve information, the memory system is not perfect and can be subject to many factors of corruption (Atkinson, 2013).

Memory Formation

The process of forming a memory is a molecular biological process (Carter et al., 2014). Miller and Matzel (2000) demonstrated that initially the brain encodes information from the external world as patterns of ongoing neural transmission, which are later stored in molecular structural formats, like new synapses. Kandel (2001) goes on to explain that to build a memory, neurons must manufacture new proteins and build new synapses.

Memory formation involves three steps: acquisition, consolidation, and storage (Tranel & Damasio, 1995). Acquisition refers to the process of bringing knowledge into the brain and into a first-stage memory buffer through the sensory organs and primary sensory cortices. Consolidation is the process of building a robust representation of the memory in the brain. Finally, storage is thought to refer to the creation of a relatively stable memory trace or record of knowledge in the brain (Tranel & Damasio, 1995).

Memory Models

Atkinson and Shiffrin (1968) proposed short-term memory was not a passive storage structure but was the part of the system where active control processes had their effects. Therefore, the system could be termed ‘working memory.’ Short-term memory was viewed as a system of multiple memories with differing modalities and characteristics (Atkinson & Shiffrin, 1968). Thus, Atkinson and Shiffrin (1968) posited there were multiple stages of processing through various short-term memories with increasingly abstract coding of the information. However, Atkinson and Shiffrin (1968) assumed working memory was a single component that handled, stored, and manipulated all types of information. New research suggests, however, that a system with specialized functions would better describe working memory (Koopmann-Holm & O'Connor, 2017).

Baddeley and Hitch’s (1974) working memory is a source-limited memory that stores and processes information temporally. The working memory model attempts to explain how information is processed in short-term memory and what happens to information when there is an emotional distractor present. The central executive component is responsible for the control and regulation of cognitive processes. It directs focus and targets information, making working memory and long-term memory work together. The central executive system controls two main systems: the phonological loop and the visual-spatial sketchpad. The role of the phonological loop is to store and recycle short-term sound or phonological information. The visual-spatial sketchpad, on the other hand, processes visual spatial information and helps store objects and images in short-term memory (Baddeley & Hitch, 1974).

However, the initial working memory model proposed by Baddeley and Hitch (1974) struggled to explain some functions of memory, like the relationship between working and long-term memory (Radvansky & Ashcraft, 2014). To address the problems of the first model a fourth component, called the episodic buffer, was introduced (Baddeley, 2000). The episodic buffer is controlled by the central executive system and can store information in multidimensional code (Baddeley, 2000). The episodic buffer helps link information across the systems and helps form meaning for visuospatial and verbal information (Baddeley, 2000).

Working Memory Capacity

Working memory capacity (WMC) describes the ability to process and store goal relevant information while inhibiting the processing of distracting material (Engle, 2002). Individual differences in WMC predict variations in higher cognitive functioning and performance on real world cognitive tasks, such as reading, the ability to process emotions, and reasoning (Garrison, & Schmeichel, 2019). Additionally, working memory is utilized in everyday life for processing tasks and meeting goal demands (Schweizer & Dalgelish, 2016).

Working Memory Capacity and Attention

Attention has been used to describe a wide range of phenomena; however, it can be best explained as the mental process of concentrating effort on a stimulus (Radvansky & Ashcraft, 2014). Additionally, attention involves several processes including focusing of attention, sustained attention, shift and dividing of attention (Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991). Like working memory capacity, attention is a limited resource (Gao, Peng, & Wen, 2014; Salthouse, Atkinson, & Berish, 2003; Wickens, 1980). In their study, Sanchez and Wiley (2006) tested people with different memory spans, giving participants text to read that included illustrations. The images provided with the text were irreverent to the main points of the passages. Results found that individual's working memory capacity performance was better when the images provided with the text were related to the main points in the passage (Sanchez & Wiley, 2006). Furthermore, the study illustrated that participants with lower memory spans were more likely to be distracted by the irrelevant details in the images (Sanchez & Wiley, 2006).

When examining free recall, participants can recall the list of items in any order (Radvansky & Ashcraft, 2014). While looking at free recall, Glanzer and Cuntiz (1966) examined whether the effects of delay manipulation had two storage mechanisms. Within their study, two groups of participants were shown a 15-item list. One group of individuals were asked to immediately recall the list (0 seconds delay) while the other group had to do an attention-consuming task for 30 seconds (Glanzer & Cuntiz, 1966). Results revealed that when asked to do an attention-consuming task, working memory capacity performance was negatively influenced (Glanzer & Cuntiz, 1966). Another way in which working memory has been assessed is through the dual task method (Radvansky & Ashcraft, 2014). In this approach, the participant completes a primary task while also doing a secondary task simultaneously (Radvansky & Ashcraft, 2014). Results from dual task method have revealed that when a distractor or interference are introduced, performance on the primary task is negatively impacted (Baddeley & Hitch, 1974; Radvansky & Ashcraft, 2014). Within the previous studies, interference takes up resources from the central executive system, thereby hindering information processing and working memory performance (Radvansky & Ashcraft, 2014). Several studies have examined immediate and delayed recall with working memory tasks and found similar results (Barth & Schneider, 2018; Bjork & Whitten, 1974; Parr & Friston, 2017; Thapar & Greene, 1993; Watkins, Neath, & Sechler, 1989).

Working Memory Capacity and Emotions

Research shows emotion and working memory are integrated (Gray, 2004). In fact, emotional information often acts as a distractor for the working memory system and limit the overall holding capacity (Schweizer & Dalgelish, 2016). Executive attention and response inhibition are found to be affected by emotional distractors, leading to decreased capacity in working memory performance (Schweizer & Dalgelish, 2016). Studies show attention in particular is negatively affected by emotional information (Baddeley, 1998; Engle, 2002; Engle, Kane, & Tuholski, 1999). Research also demonstrates that induced anxiety negatively impacts verbal and spatial working memory performance (Vytal, Cornwell, & Letkiewicz, 2013).

The influence of emotion on working memory has been explored for several decades, with increasing popularity in recent years due to its clinical relevance and influence on higher-cognitive processes, such as emotion regulation (Mikels & Reuter-Lorenz, 2019). Different types of emotional stimuli have been used in research, such as facial expressions, auditory and picture stimuli to examine the influence of emotions on executive processing (Tyng, Amin, Saad, & Malik, 2017).

A study by Schweizer and colleagues (2019) examined the influence of emotional information on working memory capacity using fMRI testing. Findings showed that emotion information impacts working memory processing in the brain, even when accuracy on working memory tasks is seemingly consistent between emotional and neutral content (Schweizer et al., 2019). Findings indicate that clinical populations responded less accurately than non-clinical control groups when emotion eliciting stimuli were included in the working memory tasks (Schweizer et al., 2019). Further, Schweizer et al., (2019) found an increased processing demand for emotional over neutral stimuli, implying that greater cognitive resources are required when emotional stimuli are present during working memory performance. By adding emotional stimuli to a working memory task, working memory capacity might become overwhelmed and lead to failures in achieving goal-directed behaviors (Chiasson, Moorman, Romano, Vezarov, Cameron, & Smith, 2021). This is problematic for some clinical populations, such as those with PTSD, since performance on working memory tasks may be negatively impacted among these clinical groups (Schweizer & Dalgleish, 2011).

Working Memory Capacity and Gender

It has long been recognized that men and women exhibit differential performance on various cognitive tasks, (Herlitz, Airaksinen, & Nordstrom, 1999; Kimura & Harshman, 1984; Maitland, Herlitz, Nyberg, Backman, & Nilsson, 2004). Gender differences of WMC have consistently been shown to occur in two domains: tests of spatial ability (spatial perception) and in tests of verbal ability (particularly verbal fluency) (Wegesin, 1998). Past literature reveals that women tend to outperform men on semantic tasks like verbal recall (Herlitz et al., 1999; Kimura & Harshman, 1984; Maitland et al.,2004) and men tend to score higher on visuospatial tasks (Bosco, Longoni, & Vecchi, 2004; Voyer, Voyer, & Bryden, 1995).

Working Memory Capacity: Verbal Recall

Baddeley and Hitch’s working memory model (1974; Baddeley, 2000) has been used to explain why gender differences may occur in verbal recall. Within this model, a phonological copy of words or items is held in the phonological loop and information is maintained through rehearsal (Baddeley, 2000). Articulation rate is a key determinant of performance in tasks such as immediate serial recall and memory span (Voyer, Aubin, Altman, & Gallant, 2021). Specifically, items that can be articulated faster are better recalled than items articulated at a slower pace (Schweickert & Boruff, 1986; Voyer et al., 2021). Supporting this theory, Hulme, Thomson, Muir, and Lawrence, (1984) showed that the large increase in working memory performance from 4 years of age to adulthood is attributable to increased speech rate. Accordingly, speech rate differences are seen when comparing men and women, showing that women tend to have a faster rate of speech (Van Borsel & De Maesschalck, 2008). Research has also shown that women may have an advantage in verbal working memory tasks because they form better phonological representations of verbal material (Majeres, 1999).

Past research found a distinction in performance between recall (direct retrieval of memorized items) and recognition (identifying memorized items in a list) suggesting that recognition is easier than recall (Cabeza, Kapur, Craik, McIntosh, Houle, & Tulving, 1997). However, recall and recognition are almost always confounded with task in memory research (Voyer et al., 2021). When examining gender differences between recall and recognition in children, May and Hutt (1974) found that girls outperformed boys in both recall and recognition tasks.

Working Memory Capacity: Numeric Recall

Regarding numeric recall, which has commonly been examined by the Forward Digit Span task, studies show inconsistent results. A study performed by Sebastián and Mediavilla (2015), examined verbal numeric recall within a Spanish population. Their study found that males performed slightly better than females however analyses showed that this effect explained less than 1% of the variance. This finding was consistent with Choi et al., (2014), who examined the numeric recall abilities of a large older adult population in South Korea. Other studies did not find significant gender differences within numeric recall (Caltagirone, & Carlesimo, 2013; GrÉGoire & Van Der Linden, 1997; Manoochehri, 2020).

Posttraumatic Stress

Posttraumatic stress is a psychological condition first defined in 1980 in the *Diagnostic and Statistical Manual of Mental Disorders* (APA, 1980). Posttraumatic stress was based on the evidence that a specific pattern of psychological phenomenology occurs in some individuals exposed to traumatic events (Figley, 2012). Traumatic events have a different quality than other types of life stresses, being characterized by people's reactions to fear, horror, and helplessness in a setting of severe threat of death or injury (Van der Kolk, 2014). While it is currently unknown as to why some individuals develop posttraumatic stress after traumatic events and others do not, research shows psychological, genetic, physical, and social factors are involved (Grinage, 2003).

Posttraumatic Stress Symptoms

Responses following exposure to a traumatic or stressful event can be quite diverse and the adverse event can be re-experienced in various ways (APA, 2013). Some common symptoms experienced by those with posttraumatic stress include repeatedly reliving the event(s) through nightmares, intrusive thoughts, or dissociative flashbacks (APA, 2013). Along with trying to avoid things or activities that remind them of the trauma, individuals also tend to view the world and themselves in a more negative way than they did prior to the traumatic experience (APA, 2013). Lastly, following a traumatic event, the individual can also experience hyperarousal, irritability, trouble concentrating, and sleep problems (APA, 2013).

Posttraumatic Stress and Cognition

Studies increasingly show links between trauma exposure, posttraumatic stress symptoms, and cognitive functioning (Blanchette et al., 2018). Additionally, cognitive dysfunction in PTSD is a significant predictor of low social functioning (Geuze, Vermetten, Kloet, Hijman, & Westenberg, 2009). While PTSD and cognition are more often examined within veteran populations, Sumner et al. (2017) found decreased cognitive performance of verbal memory, speed, and attention in a large cohort of middle-aged women with posttraumatic and depressive symptoms. Furthermore, a study revealed that as they age, individuals with PTSD are at greater risk of developing dementia when compared to a control group (Yaffe et al., 2010).

In addition to studies revealing that higher rates of PTSD are associated with decreased cognitive functioning, Meyer and colleagues (2018) aimed to examine how specific symptoms of PTSD influenced cognitive functioning. Within their study, negative alterations in cognitions, mood, and symptoms of intrusion were associated with decreased cognitive functioning (Meyer et al., 2018). The researchers also identified a difference between men and women in the relations between the PTSD symptom clusters and functional impairment. In men, negative alterations in cognition and mood were the only symptom cluster related to decreased cognition, whereas in women, arousal and reactivity were more commonly linked with lower performance (Meyer et al., 2018).

Posttraumatic Stress and Working Memory Capacity

PTSS is associated with decreased performance in verbal memory, short-term memory, attention, and executive functions (Scott et al., 2015). Research consistently finds verbal memory deficits, such as difficulty remembering a list of words or a story, in individuals with PTSD (Gilbertson, Gurvits, Lasko, Orr, & Pitman, 2001; Van der Kolk, 2014; Wild & Gur, 2008). Squire (2004) found that verbal memory deficits in the aftermath of trauma were linked to later development of PTSD. Additionally, another study found that verbal memory deficits did not characterize all patients with PTSD, but only those who later failed to recover with standard psychological treatment for the disorder (Wild & Gur, 2008).

Individuals with PTSD may experience intrusive thoughts from internal or external factors which could diminish working memory accuracy in everyday tasks by detracting attention from the task being worked on (Chiasson et al., 2021). For example, Schweizer and Dalgleish (2011) found that, when sentences included traumatic content, those with current PTSD recalled fewer words than controls with similar trauma history who never met criteria for a PTSD diagnosis. These findings suggest that individuals with PTSD experience inhibition in their ability to use working memory when emotional content is present (Schweizer & Dalgleish, 2011).

Furthermore, reductions in attention produce significant limitations in memory (Carter et al., 2014). Studies of veterans with PTSD show poorer performance on measures of attention compared to veterans without PTSD (Gilbertson et al., 2001). Gilbertson and colleagues (2001) found the link between memory problems and PTSD sustained even after controlling for attentional difficulties. Another study found that compared to veterans without PTSD, those with PTSD had difficulties finding and self-correcting errors made on specific tasks (Kendel, 2001). This further suggests that PTSD symptoms may be overtaxing the central executive functions in the brain, contributing to difficulties performing daily tasks (Kendal, 2001).

Posttraumatic Stress and Gender

Studies on PTSD show the disorder and its presentation vary by gender (APA, 2013; Tolin & Foa, 2006). A variety of factors are proposed to explain these differences, including gender-specific exposures, trauma types, pretrauma risk factors, differences in coping, and cognitive appraisals (APA, 2013). Accordingly, the lifetime prevalence of PTSD is about 10% to 12% in women and 5% to 6% in men (APA, 2013; Kilpatrick et al., 2013). This means women are more than twice as likely to develop the disorder compared to men (APA, 2013). Lastly, women tend to experience PTSD symptoms for a longer duration compared to men (Kessler et al., 1995).

Furthermore, gender differences exist in how men and women experience PTSS (Charak et al., 2014). Charak and colleagues (2014) found re-experiencing and anxious arousal were increased in women whereas men were more likely to endorse avoidant symptoms of PTSD. However, regardless of study type, population, or means of assessment women and girls were more likely than men and boys to meet criteria for PTSD (Benjet et al., 2016). This is consistent with epidemiological research showing a higher prevalence of fear and anxiety-based disorders among women (APA, 2013; Benjet et al., 2016; Bourdon et al., 1988).

Past literature also suggests that women exhibit more cognitive symptoms of PTSD (e.g., self-blame and negative alterations in cognitions about oneself, others, and the world) than men and therefore may have a greater cognitive vulnerability to PTSD (Cox, Resnick, & Kilpatrick, 2014). Research on trauma-related appraisal shows that psychopathological reactions to stress are influenced not only by the severity of the traumatic event, but also by the cognitive appraisals of the event (Brewin & Holmes, 2003; Janoff-Bulman, 1992; Tolin & Foa, 2002). Thus, some literature found that the subjective interpretation of the event, as opposed to the objective fact of being exposed to trauma influences the risk of developing mental disorders (Olff, Langeland, Draijer, & Gersons, 2007).

Research shows that while more than half of the general population will experience at least one traumatic event over their lifetime, men experience a significantly higher frequency of lifetime trauma exposure when compared to women (Benjet et al., 2016; Breslau, Davis, Andreski, Peterson, & Schultz, 1997; Ditlevsen & Elklit, 2012; Kessler et al., 1995). However, there are distinct gender-related patterns of trauma exposure, where men are more likely to experience physical assault, community and political violence, automobile accidents, and combat exposure (Benjet et al., 2016; Tolin & Foa, 2006; van der Meer et al., 2017) and women experience higher rates of sexual assault, molestation, and childhood physical abuse (Benjet et al., 2016; Freyd, Klest, & Allard, 2005; Tolin & Foa, 2006; Ullman, & Filipas, 2005; Van der Meer et al., 2017). The type of trauma experienced by individuals impacts the prevalence of PTSD (Farhood, Fares, & Hamady, 2018; Kessler et al., 1995). Specifically, women are at higher risk for interpersonal traumas (42.4%) compared to men (15.8%) and these types of traumas result in a greater risk for PTSD (Kilpatrick et al., 2013).

Summary of Research

The most prevalent adverse consequence of trauma is posttraumatic stress symptoms (APA, 2013). PTSS reflects an abnormal biological and psychological response to stress (Van der Kolk, 2014). Current research shows links between PTSD, the hippocampus, and cognitive deficiencies, such that individuals with higher rates of PTSS displayed impairment in learning and memory functioning (Blanchette, Rutembesa, Habimana, & Caparos, 2018; Van der Kolk, 2014). Additionally, Wild and Gur (2008), found lower cognitive functioning in individuals adversely affects the response toward psychological treatment of PTSD.

While literature shows differences between men and women’s working memory abilities (Meyer et al., 2018), little research is available on how PTSS influences an individual’s working memory capacity. Furthermore, while cognitive decline and PTSS are heavily studied among older adults and military personnel, research is lacking among younger, non-military populations (Sumner et al., 2017). Among college students, 81.8% report experiencing at least one traumatic event in their lifetime, and approximately one third of those report symptoms consistent with PTSD (Overstreet, Berenz, Kendler, Dick, & Amstadter, 2017). Prospective studies show that trauma-exposed college students who develop PTSD are more likely to exhibit impairment in functioning (e.g., academic and social; Overstreet et al., 2017) as well as co-morbid physical, mental, and behavioral health problems (e.g., chronic pain, depression, and substance use; Kessler et al., 1995; Overstreet et al., 2017).

Additionally, posttraumatic stress research has long reported gender differences in the experience of trauma; specifically with women and girls being more likely diagnosed with PTSD, even though they experience fewer traumas compared to men and boys (APA, 2013; Gavranidou, & Rosner, 2003; Kessler et al., 1995). However, trauma research is lacking among young women who have experienced significant stressors and may have cognitive deficiencies (Sumner et al., 2017).

Current Study

This study aimed to further examine the relationship between posttraumatic stress and gender. I also hoped to gain more information about the impact of PTSS on working memory capacity within a college sample because little research is available in this area with this specific population. While examining the relationship between PTSS, gender and working memory, this study also further explored the moderating effects of gender and PTSS on working memory capacity in a college population. Specifically, the working memory categories of verbal and numeric recall which were examined through specific tasks and questionnaires.

Hypotheses

It was hypothesized that greater reported PTSS would relate to lower working memory ability for both men and women in the working memory categories of verbal and numeric recall. Lastly, the effects of gender as a moderator between PTSS and the working memory tasks were examined. Specifically, the hypotheses were:

1) Consistent with previous research, it was expected that as posttraumatic stress symptoms increased, working memory capacity would decrease (Blanchette et al., 2018).
2) Consistent with past literature, gender differences were expected on PTSS symptoms, with women reporting more symptoms compared to men (APA, 2013; Tolin & Foa, 2006).
3) Previous literature demonstrates gender differences in memory performance (Herlitz, Airaksinen, & Nordstrom, 1999; Voyer, Voyer, & Bryden, 1995). Within the current study, similar gender differences among participants were expected.

3a) Compared to men, women were expected to demonstrate greater verbal recall (Bell et al., 2006; Meyer et al., 2018).

Study Aims

1) Due to inconclusive findings in the literature, the correlation between gender and numeric recall is unknown and was explored further within this study (Caltagirone, & Carlesimo, 2013; GrÉGoire & Van Der Linden, 1997; Manoochehri, 2020)
2) To date, no known research explored potential moderating effects of gender on the relationship between PTSD symptoms and working memory tasks. Therefore, the effects of gender as a potential moderator between PTSD symptoms and verbal and numeric recall were examined.

CHAPTER 2

METHOD

Participants

Participants were 254 undergraduate students (76.2% women, 23.3% men, 0.5% other genders) at a mid-sized southeastern university. A total of 50 participants were excluded from analysis because of incomplete data, yielding a total of 204 participants for analyses. Participants' ages averaged 19.7 years (*SD* =3.83), with ages ranging from 18 to 45 years. Participants' ethnicities included White/Caucasian (63.2%), Black/African American (24.4%), Multi-Racial (4.5%) Hispanic (4%), Asian/Pacific Islander (3%), and other ethnicities (1%). See Table 1 for participant demographics.

Participants were recruited through the campus Experiment Management System (SONA). SONA Systems notifies potential participants of available studies for participation and can be used on any online-based device. To qualify for this study, individuals had to be at least 18 years old or older. There were no other inclusion/exclusion criteria. Throughout this study, the confidentiality of the participants was maintained and regulations set by the Institutional Review Board (IRB) were followed.

Procedure

Data were collected through an online collection tool (*Qualtrics*). Prior to answering the survey questions and completing the tasks, participants read the informed consent document. The informed consent document broadly explained the nature of the study, risks, benefits of participating, and other pertinent information related to the participant's rights. If the participant consented to participating in this research study, they chose the option, "I freely consent to participate in this study." Once the participant agreed to participate, the study began and these steps were followed:

1. Participants completed the PTSD Checklist – Civilian Version.
2. Participants completed both tasks below in random order. Tasks were randomized using the block randomizer tool on Qualtrics:
    i. Auditory Verbal Recall Test/Demographics: Participants opened an auditory file and listened to a researcher read 15 words at the rate of 1 per second. Once the auditory file ended, participants saw a randomized list of 30 words including the 15 words they heard and 15 distractor words. Participants marked each of the 30 words as "Heard on Recording" or "Not Heard on Recording." Then, participants provided demographic information on the Demographic Questionnaire. Upon completing the Demographic Questionnaire, participants again saw the list of 30 words including the 15 words they previously heard and the same 15 distractor words. Participants marked each of the 30 words as "Heard on Recording" or "Not Heard on Recording." This allowed the examination of the effects of interference on working memory capacity. See Appendix A for the list of target and distractor words. See Appendix B for the list of demographic questions addressed.
    ii. Forward Digit Span: Participants opened a series of auditory files. There they heard a researcher read a sequence of numbers at the rate of 1 per second. Once the auditory file ended, participants typed in the numeric sequence they just heard. The first auditory file contained a sequence of two digits. Each subsequent numeric auditory file got progressively more difficult from 2-digit spans to 10-

digit spans. For instance, the participant heard the auditory file say, “Please listen to the following numbers as they are read out loud… 4, 7.” See Appendix C for the list of numeric sequences used.

3. Participants read the debriefing and instructions to receive credit for completing the study.

Measures

PTSD Checklist – Civilian Version (PCL-C, 1994). The PCL-C is a self-report measure of PTSD symptom severity which corresponds to 17 core DSM-IV PTSD symptoms (Weathers et al., 1994). The PCL-C is not linked to a specific event; the questions refer to "a stressful experience from the past" (Weathers et al., 1994). Participants rate each item from 1 ("not at all") to 5 ("extremely"), indicating the degree to which they were bothered by that symptom over the past month (Weathers et al., 1994). The PCL-C is one of the most commonly used self-report measures of DSM-IV PTSD symptom severity, and it has demonstrated excellent psychometric properties across a range of samples and settings (Blevins, Weathers, Davis, Witte, & Domino, 2015; Norris & Hamblen, 2004).

In a study of trauma-exposed undergraduate students, the PCL-C demonstrated good retest reliability and internal consistency as well as good convergent and discriminant validity (Adkins, Weather, McDevitt-Murphy, & Daniels, 2008). Additionally, when examining a nonclinical sample of undergraduate students, the PCL-C showed good internal consistency ($\alpha = .94$, $n = 471$) and retest reliability ($\alpha = .92$, $n = 316$; Conybeare, Behar, Solomon, Newman, & Borkovec, 2012). Summed scores range from 17 to 85, with higher scores indicating higher PTSD symptom severity. High diagnostic efficiency was found using a cutoff score of 50 (Blanchard, Hickling, Buckley, Taylor, Vollmer, & Loos, 1996). The PCL-C was used to assess PTSS in this study.

Auditory Verbal Recall Test (AVR). The AVR contains a list of 15 target words that the examiner reads in one second intervals. Once all the words on the list were read, the participant was shown a randomized list of 15 target words and 15 distractor words. The participant then selected as many target words as possible. The AVR test was adapted from similar verbal recall tests, like the Rey Auditory Verbal Learning Test (RAVLT, 1996), which has been retested numerous times in areas of acquisition, storage, and retrieval (Fichman et al., 2010; Malloy-Diniz, Lasmar, Gazinelli, Fuentes, & Salgado, 2007; Schmidt, 1996). Previous findings from the REVALT show excellent reliability ($\alpha = .84$; de Sousa Magalhães, Malloy-Diniz, & Hamdan, 2012). The test condition coefficients range from .78 to .82, and the retests range from .81 and .86 (de Sousa Magalhães et al., 2012). Previous literature found that individuals can recall an average of seven words, with a deviation of plus/minus two words (Schmidt, 1996). Within the current study, the AVR was used to assess immediate and delayed verbal recall. To allow for a delayed recall, participants completed the demographics questionnaire directly following the immediate recall task. Scores were assessed by the correct number of target words selected, this was done for immediate and verbal recall.

Forward Digit Span. During the Forward Digit Span Task, the participants listened to a research-created auditory YouTube recording. Participants then would type in the numbers they recalled hearing in the same order presented. Over the course of the task, the number sequences got longer, from a two-digit sequence to a ten-digit sequence. A typical forward digit span for adults is recalling a seven-digit span, with a standard deviation of two (Lezak, 1995). Scores were taken from the highest correct sequence recalled, if preceding two sequences were also correct.

Demographics Questionnaire. Participants completed a 6-item questionnaire to evaluate current demographic information (e.g., age, gender, major, and any previous or current academic accommodations. This questionnaire captured the main independent variable being examined, gender.

TABLE 1

Table 1. Participant Demographics

Variables	Mean	Standard Deviation
Age	19.70	3.83
	Frequency	Percent
Gender		
Women	154	76.2
Men	47	23.3
Other	1	0.5
Missing	2	1.0
Ethnicity		
Caucasian	127	63.2
African American	49	24.4
Multi-Racial	9	4.5
Hispanic	8	4.0
Asian/Pacific Islander	6	3.0
Other	2	1.0
Missing	3	1.4

CHAPTER 3

RESULTS

Preliminary Analyses

The data were examined to determine the distribution of PTSS scores for participants (*M* = 42.74, *SD* = 16.31). To evaluate whether these effects violated the normal distribution, the skewness of the data were evaluated. Results revealed skewness to be 0.28 with a standard error of 0.17. In addition, the kurtosis of the distribution was evaluated. Results revealed a value of -0.88 with a standard error of 0.34. The distribution is illustrated in a histogram (See Figure 1). Overall, results from the Shapiro-Wilk analysis indicated the data were non-normally distributed, $W(204) = .964$, $p < .000$, in a manner consistent with a positive skewed pattern. This indicates that there were more participants with lower PTSS scores than would be expected in a normal distribution. This was consistent with expectations since this study examined a non-clinical population for PTSS. Furthermore, the skew was not extreme, and analyses are robust despite some violations of normality (Mertler & Reinhart, 2017). See Table 2 for descriptive statistics.

Bivariate Correlations

Bivariate correlations were conducted to examine relationships among gender, posttraumatic stress symptoms, and working memory capacity. Results were consistent with previous research. Specifically, of most interest was whether higher levels of posttraumatic stress symptoms were significantly associated with a decrease in verbal and numeric recall. See Table 3 for all bivariate correlations.

When examining the relationship between gender and PTSS, gender was positively correlated with PTSS scores, indicating that women displayed higher rates of PTSS compared to men, $r(202) = .141$, $p < .05$. Consistent with expectations, performance on one working memory task was positively correlated to the performance on the other task. Specifically, analyses revealed that immediate and delayed verbal recall were positively correlated, $r(198) = .870$, $p < .01$. Immediate verbal recall and numeric recall were also significantly correlated $r(199) = .158$, $p < .05$. Surprisingly, analyses revealed no significant correlations between working memory performance and PTSS: immediate verbal recall ($r = .003$), delayed verbal recall ($r = .050$), numeric recall ($r = -.006$). Furthermore, there was no significant correlation between gender and working memory performance: immediate verbal recall ($r = .076$), delayed verbal recall ($r = .045$), numeric recall ($r = -.030$).

Primary Analyses

To test the hypothesis that higher posttraumatic stress symptoms account for lower working memory performance, and more specifically whether gender moderates the relationship between PTSS and working memory capacity, three hierarchical multiple regression analyses were conducted for each dependent variable: immediate verbal recall, delayed verbal recall, and numeric recall. This analysis is consistent with previous literature examining cognitive performance and PTSD (Beck, Reich, Woodward, Olsen, Jones, & Patton, 2015; Meyer et al., 2018). For all models, in the first step PTSS was entered and in the second step gender was entered.

When examining immediate verbal recall these variables accounted for no significant amount of variance in working memory capacity, $R^2 = .006$, $F(2,196) = 0.57$, $p = .56$. Although the regression analyses showed to be nonsignificant, an interaction effect was tested to determine if gender was negating the results between immediate verbal recall and PTSS for all models. To avoid potentially problematic high multicollinearity with the interaction term, the variables were centered and an interaction term between PTSS and gender was created for all models (Aiken &

West, 1991). The interaction term between PTSS and gender was added to the regression model, this accounted for a nonsignificant proportion of the variance in immediate verbal recall performance ΔR^2 = .009, F(1, 195) = 1.72, p = .413, b = .043, t(195) = -1.31, p =.191. See Table 4 for regression results on immediate verbal recall.

Regression analyses for delayed verbal recall again accounted for no significant amount of variance in working memory capacity, R^2 = .004, F(2,196) = 0.39, p = .68. When the interaction term between PTSS and gender was added to the model, this again accounted for a nonsignificant proportion of the variance in delayed verbal recall ΔR^2 = .001, F(3, 195) = 0.167, p = .813, b = -.014, t(195) = -.409, p = .683. See Table 5 for regression results on delayed verbal recall.

Regression analyses for numeric recall also accounted for no significant amount of variance in working memory capacity, R^2 = .001, F(2,199) = 0.098, p = .91. When the interaction term between PTSS and gender was added to the model, this also accounted for a nonsignificant proportion of the variance in numeric recall ΔR^2 = .007, F(2, 199) = 1.454, p = .648, b = -.025, t(199) = 1.206, p = .229. See Table 6 for regression results on numeric recall.

FIGURE 1

Frequency of Posttraumatic Stress Symptoms (PTSS): Histogram

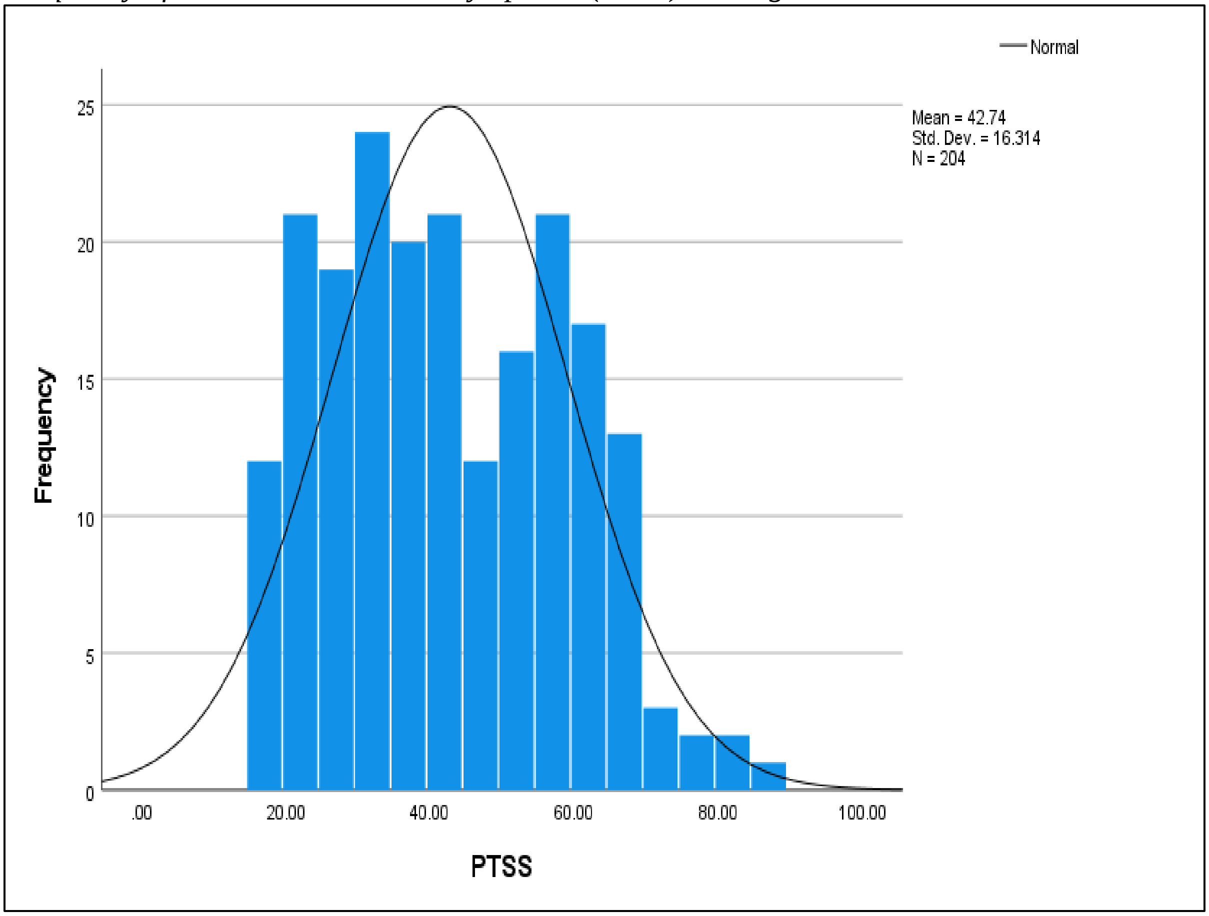

TABLE 2

Table 2. Participant Descriptive Statistics

Variables	Men			Women			Total		
	M	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*N*
PTSS	38.69	15.64	45	43.90	16.48	152	42.75	16.37	197
Verbal Recall-I	10.67	3.66	45	11.16	2.81	152	11.06	3.02	197
Verbal Recall-D	10.64	3.71	45	10.88	3.08	152	10.83	3.22	197
Numeric Recall	4.29	1.75	45	4.42	2.10	152	4.39	2.02	197

TABLE 3

Table 3: Pearson r Correlation Matrix among Measures of PTSS, Verbal Recall Immediate, Verbal Recall Delayed, Numeric Recall, and Gender

	1	2	3	4	5
PTSS					
Verbal Total Immediate Recall	0.003				
Verbal Total Delayed Recall	0.05	.870**			
Numeric Total	-0.006	.158*	0.104		
Gender	.141*	0.076	0.045	0.03	

Note: *Correlation is significant at the .01 level. ** Correlation is significant at the .001 level**.**

TABLE 4

Table 4: Regression Statistics for the Main and Interaction Effects of PTSS and Gender on Immediate Verbal Recall

Variables	*b*	*SE*	*t*	*p*	LLCI	ULCI
Constant	11.08	0.23	50.91	.00	10.65	11.51
PTSS	-0.0009	0.01	-0.07	.94	-0.03	0.03
Gender	0.44	0.52	0.85	.40	0.58	1.45
PTSS x Gender	-0.04	.0326	-1.31	.19	-0.11	-0.02

Note. LLCI = lower level confidence interval; ULCI = upper level confidence interval.

TABLE 5

Table 5: Regression Statistics for the Main and Interaction Effects of PTSS and Gender on Delayed Verbal Recall

Variables	*b*	*SE*	*t*	*p*	LLCI	ULCI
Constant	10.82	0.23	46.68	.00	10.36	11.28
PTSS	0.01	0.01	0.63	.53	-0.02	0.04
Gender	0.26	0.54	0.48	.63	-0.81	1.33
PTSS x Gender	-0.01	0.03	-0.41	.68	-0.08	0.05

Note. LLCI = lower level confidence interval; ULCI = upper level confidence interval.

TABLE 6

Table 6: Regression Statistics for the Main and Interaction Effects of PTSS and Gender on Numeric Recall

Variables	*b*	*SE*	*t*	*p*	LLCI	ULCI
Constant	5.95	1.63	3.65	.0003	2.74	9.17
PTSS	-0.05	0.04	-1.20	.23	-0.12	0.03
Gender	-0.88	0.91	-0.96	.34	-2.67	0.92
PTSS x Gender	0.03	0.02	1.21	.23	-0.02	0.07

Note. LLCI = lower level confidence interval; ULCI = upper level confidence interval.

CHAPTER 4

DISCUSSION

Review of Purpose

The main purpose of the current study was to examine the relationship between posttraumatic stress symptoms (PTSS) and working memory capacity (verbal and numeric recall) among an undergraduate population. Specifically, this study examined whether gender acted as a moderator between PTSS and working memory capacity. Review of the literature revealed that individuals who displayed lower cognitive functioning tended to respond worse to standard psychological treatment for PTSD (Wild & Gur, 2008). Thus, by further examining the relationship between cognitive functioning and PTSD these outcomes may contribute to more effective treatment options for mental health professionals. The following questions were examined: (a) are there PTSS score differences by gender? (b) are higher levels of PTSS related to decreased working memory capacity for verbal and numeric recall? (c) is there a gender difference in performance on working memory tasks? Specifically, did women perform better in verbal recall compared to men? (d) was gender correlated with numeric recall? and (e) did gender moderate the relationship between PTSS and working memory performance? Posttraumatic stress symptoms were retained as the predictor variable.

Discussion of Findings

Relationship between Gender and PTSS

A positive relationship between gender and PTSS was expected, and the findings were consistent with previous literature (APA, 2013). Women in the current study reported higher scores on the PCL-C compared to men *($p < .05$)*. Women have significantly higher lifetime PTSD prevalence rate (12.8%) compared to men (5.7%; APA, 2013; Kilpatrick et al., 2013).

Furthermore, women tend to experience PTSD symptoms for a longer duration compared to men (Kessler et al., 1995). Women are more likely to experience interpersonal trauma like domestic abuse, sexual assault, and or childhood abuse compared to men, which likely explains gender differences in prevalence rates of PTSD (Freyd et al., 2005). These trauma types tend to elicit more dissociation, greater shame, lower self-esteem, and more distress compared to traumas that are intrapersonal such as combat, disaster, vehicle accidents (Freyd et al., 2005; Ogle et al., 2013).

Relationship between PTSS and Working Memory Capacity

A negative relationship between PTSS and working memory capacity was expected; however, no significant correlations were found between PTSS and working memory capacity. Results suggest that PTSS was not related to WMC in the current study. Several factors may have impacted the findings.

First, the sample consisted of a non-clinical college sample. The mean PCL-C scores averaged 38.7 for men and 43.9 for women. Scores for the PCL-C can range from 17 to 85, with higher scores indicating higher PTSS severity. High diagnostic efficiency has been found using a cutoff score of 50 on the PCL-C, indicating that individuals who score above 50 may have PTSD (Blanchard et al., 1996). From the mean scores of men and women in the current sample, it appears there were lower levels of PTSS than the cutoff for clinical significance. The PCL-C scores in this college sample are similar to those found in college samples where nonclinical undergraduate populations had mean PCL-C scores of 29.1 (N = 471; Viana et al., 2020) and 41.1 (N = *99*; Conybeare et al., 2012). Furthermore, while research shows a correlation between PTSS and WMC in clinical populations (Baca, Crawford, & Allard, 2021; Gilbertson et al., 2001; Schweizer & Dalgleish, 2016; Van der Kolk, 2014), some research examining non-clinical populations did not find the same effect (Meyer et al., 2020; Schick, Weiss, Contractor, Suazo & Spillane, 2020; Schweizer & Dalgleish, 2016).

Some literature reveals that the influence of affective distractors on WMC and PTSS do not negatively impact college samples (Mirabolfathi, Moradi, & Jobson, 2019; Schick et al.,2020). It is possible that the PCL-C assessment, which was used as an emotional distractor in this study, did not activate intrusive memories in the sample. Some researchers who examined clinical populations of PTSD, utilized PTSS questionnaires to help illicit intrusive memories (Mirabolfathi, Schweizer, Moradi, & Jobson, 2020; Witkin, Denkova, Zanesco, Llabre, & Jha, 2021). Intrusive thoughts take resources from working memory and diminish the ability to work on the task at hand (Chiasson et al., 2021; Schweizer & Dalgleish 2011; 2016). However, clinical groups with PTSD may be more sensitive to affective distractors and experience more intrusive thoughts and the distraction may not need to be as emotionally taxing as that for a non-clinical group. Within the current study, participants were asked to complete the PCL-C before moving forward to the memory tasks.

Specific trauma history was not assessed in the current study. It is possible that in this non-clinical sample, the PCL-C questionnaire did not illicit a significant degree of intrusive memories or symptoms to impact WMC. Lastly, those with clinical PTSD may utilize avoidance more when presented with a trauma-relevant stimulus, which in turn would increase the demands of WM and decrease task performance. The relationship between specific PTSD criteria and working memory capacity needs to be examined further in future studies.

Future studies may also benefit from examining the relationship between Grade Point Average (GPA) and PTSD severity in a college population. It can be presumed that even if a student has a clinical diagnosis of PTSD, their symptoms are at a functional level, which allows them to meet classroom demands, despite their symptoms. Similarly, recent research is emerging that indicates working memory tasks may be beneficial in mitigating decreased cognitive performance and overall symptoms of anxiety, depression, and PTSD (Beloe, & Derakshan, 2020; Larsen et al., 2019). In their research, Beloe and Derakshan (2020) induced cognitive plasticity in a group of subclinical anxious and depressed adolescents by gradually increasing the complexity of WM tasks over a 4-week training period. Their findings revealed an increase in WMC as well as lower depression and anxiety scores, which were reexamined a month after training (Beloe, & Derakshan, 2020). Similarly, Larsen and her colleagues (2020) instructed a group of veterans with clinical PTSD to complete online working memory tasks for five weeks. While results showed no significant improvement in WMC, participants displayed a reduction in PTSD symptoms after the training (Larsen et al., 2020). Both studies point to the adaptive benefits of working memory training and have cognitive and clinical implications for treatments going forward.

Lastly, the data process of using an online format to complete memory tasks may have been flawed. Within their study, Al-Salom and Miller (2017) examined the effectiveness of online data collection within an undergraduate sample, and their findings showed that individuals who are prone to attention problems and/or have elevated levels of life stressors did worse when compared to control groups. Additionally, the current study occurred outside of a lab setting; this reduced our ability to monitor and control the environment. Through this format there was no way to prevent participants from using additional assistance to complete tasks (e.g., help from others, writing down presented stimuli). Also, there was no way to control for or correct any technological issues. Future studies would benefit from using a lab setting to collect data on memory performance to ensure quality data and environmental control during memory tasks.

Gender and Working Memory Capacity

A gender difference was expected for working memory. Specifically, it was expected that compared to men, women would demonstrate greater verbal recall. When examining verbal recall (immediate and delay) women did perform slightly better than men in both categories but results were nonsignificant. Findings indicate that gender may not influence verbal recall in immediate or delayed categories. While past literature shows strong evidence for a gender difference on verbal working memory tasks (Bell et al., 2006; Herlitz et al., 1999; Kimura & Harshman, 1984; Maitland et al., 2004; Meyer et al., 2018), current findings may be impacted by several factors. First, as stated previously, the fact that the study occurred outside of a lab setting may have negatively influenced results.

Furthermore, despite evidence that gender differences exist in verbal working memory, some research shows a lack of performance differences between men and women (Hill, Laird, & Robinson, 2014; Lejbak, Crossley, & Vrbancic, 2011; Voyer et al., 2021). Interestingly, through neuroimaging, Hill et al. (2014) found that while gender does account for neurofunctional differences during working memory performance, no behavioral differences were detected. Specifically, fMRI results found that during verbal working memory tasks, men activate more regions in their right hemisphere while women utilize the left hemisphere more often (Hill et al., 2014).

In this study, the relationship between numeric recall and gender was also explored. Past literature indicates mixed findings (Caltagirone, & Carlesimo, 2013; Manoochehri, 2020) and few studies have explored this category of working memory. For the current study, there were no significant difference on numeric recall between women and men. Currently, it is not fully understood why research displays gender differences for verbal recall but not for numeric recall. This area of working memory needs to be examined further.

Moderation Model

Since no known research has explored the moderating effects of gender on the relationship between PTSS and working memory tasks, this relationship was examined in the current study. Although no significant findings between gender and working memory capacity were discovered, a moderation analysis was conducted to determine if gender was negating the results between WMC and PTSS. Findings from the moderation were nonsignificant for all models. Findings suggest gender did not influence the relationship between PTSS and WMC.

Several factors may have contributed to these findings. Past literature and the current results do indicate that gender is related to the prevalence of symptoms of PTSD (APA, 2013; Tolin & Foa, 2006). Furthermore, literature reveals that PTSS is negatively correlated with WMC (Baca et al., 2021; Gilbertson et al., 2001; Schweizer & Dalgleish, 2016; Van der Kolk, 2014). Lastly, past literature shows a gender difference in working memory tasks (Bell et al., 2006; Herlitz et al., 1999; Kimura & Harshman, 1984; Maitland et al., 2004; Meyer et al., 2018). Although from past literature it can be assumed that gender influences the relationship between PTSS and WMC, it is possible that these associations are bidirectional. Specifically, an individual's gender may not influence the relationship between PTSS and WMC. Future research should address this and possibly examine this relationship among clinical samples of individuals with a PTSD diagnosis.

Study Limitations

Although findings of the present study added to the literature on the relationship between PTSS, gender and working memory capacity, findings should be considered within the context of the study's limitations. First, this study relied exclusively on self-report measures of PTSD symptom severity, which may be influenced by participants' willingness and/or ability to report accurately. Future studies would benefit from the inclusion of standardized clinical interviews to establish diagnoses (e.g., Clinician Administered PTSD Scale for DSM-5; APA, 2013). Secondly, past literature on working memory capacity has illustrated that visuospatial recall is the most significant gender related working memory task. Within the current study, this variable was unable to be included due to the necessity to collect data via online surveys (due to the COVID-19 pandemic). Future studies may be able to see gender differences in working memory capacity if this variable is included.

Further, although college students are at heightened risk for experiencing some types of traumatic events (e.g., sexual assault; Kilpatrick et al., 2013), the current study utilized self-reported symptoms from a nonclinical population. The results may not generalize to other populations. As such, further research is needed to speak to the robustness of the findings in larger, more diverse samples.

While the time of completion and response accuracy within this study was similar to other studies of this design (Al-Salom and Miller, 2017; Mirabolfathi et al., 2019), no attention checks were used within the study. Future studies would benefit from adding attention checks to the survey design to help ensure data quality and to better differentiate between low- and high-quality responses. Lastly, data collection for the current study took place during the COVID-19 global pandemic. Due to the risk of viral transmission during data collection, the planned in-person study was moved to an online format. While this allowed safe data collection, it may have also contributed to nonsignificant findings. Specifically, there was no way to ensure the integrity of working memory tasks in the online format. Participants may have misunderstood directions, written down presented stimuli, or had technological difficulties or other problems that rendered the data problematic. Future studies would benefit from collecting cognitive based data within a controlled lab setting to better control study integrity.

Strengths and Future Directions

Although performing this study outside of a lab setting added challenges and may have contributed to nonsignificant findings, data collection occurred during the COVID-19 pandemic shutdown. This virus is unprecedented and its full impact on social, cognitive, and academic/occupational factors is still unknown. For this reason, the current study has helped add new and current information to data collection and research methodology. Specifically, during this time, individuals are trying to find innovative ways of completing tasks while not compromising on the integrity of their results. However, performing WMC tasks through a virtual platform was shown to be challenging, particularly when examining cognition. This study supports previous findings which illustrate that an online format is not suitable for memory task data collection (Al-Salom, & Miller, 2017). Future studies would benefit from examining other design options or collecting data in-person if possible.

Almost without exception, traditional span tasks require short-term retention of emotionally neutral information (Gao et al., 2014; Glanzer & Cuntiz, 1966; Salthouse, et al., 2003; Sanchez & Wiley, 2006; Wickens. 1980). This study also provides a foundation to further examine the relationship between cognitive performance, PTSS, gender and emotional distraction. Specifically, future studies may benefit from extending this research by exploring the relationship between PTSS, gender, and emotional working memory. Specifically, by examining the relationship between PTSS and WMC when the tasks contain emotionally laden content. Furthermore, due to the fact that PTSD and depression rates indicate high comorbidity (APA,

2013) future studies may find it beneficial to examine the relationship between PTSS, depression, and cognitive performance within an undergraduate population.

Prospective studies continue to show that trauma-exposed college students who develop a clinical diagnosis of PTSD are more likely to exhibit impairment in functioning (e.g., academic and social; Overstreet et al., 2017), thus the results of this study have practical implications within the academic environment. Specifically, it may be beneficial for educators to provide accommodations for students during lectures and assignments (e.g., audio recordings, trigger warnings, or assignment extensions). The study also holds clinical implications and could be used to better understand and build upon clinical treatment plans for similar samples. Specifically, the results from the current study may be used to examine differences between non-clinical and clinical groups of individuals with PTSD. Furthermore, while cognitive training falls outside of the purview of traditional psychological interventions, memory task training may be beneficial for individuals outside of sessions or in conjunction to some treatment plans.

General Conclusion

Although working memory capacity, PTSS, and gender are socially and scientifically important to understand, few studies have addressed how these factors influence each other. This study examined whether PTSS and gender are correlated with working memory performance in verbal and numeric recall and specifically if gender moderates the relationship between PTSS and WMC. Gender did not moderate the relationship between PTSS and WMC. Results illustrated the need to re-examine the questions proposed in a lab setting. Lastly, results indicate that further research is needed to understand the relationship between gender, PTSS, and WMC, especially in non-clinical college samples.

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APPENDIX A

AUDITORY VERBAL RECALL TEST: WORD LIST

Target Words	**Distractor Words**
House	Curtain
Pencil	Duck
Bird	Mountain
Moon	Farmer
Color	Sky
Glove	Purse
Love	Bell
Cord	Coffee
River	Glasses
Noise	Towel
Stove	Kind
Shoe	School
Boat	Top
Plant	Water
Step	Mouse

APPENDIX B
DEMOGRAPHICS QUESTIONNAIRE

Age: ___________

Gender:

☐ Male ☐ Female ☐ Transgender ☐ Other

Race/Ethnicity:

☐ White ☐ African American ☐ Hispanic/Latino ☐ Asian ☐ Pacific Islander

☐ Native American ☐ Bi/Multi Racial: _______________________ ☐ Other: ____________________

Sexual Orientation:

☐ Heterosexual ☐ Lesbian/Gay ☐ Bi-Sexual ☐ Undecided ☐ Other

What is your current major? ____________________

Current year in school?

☐ Freshman ☐ Sophomore ☐ Junior

☐ Senior ☐ Post baccalaureate ☐ Graduate student

APPENDIX C

FORWARD DIGIT SPAN

Span = 2	5, 4
Span = 3	6, 8, 7
Span = 4	7, 3, 9, 2
Span = 5	9,1, 6, 3, 5
Span = 6	2, 4, 7, 6, 8, 1
Span = 7	6, 2, 9, 7, 8, 6, 5
Span = 8	8, 5, 7, 2, 9, 1, 3, 6
Span = 9	7, 9, 4, 8, 3, 1, 2, 6, 5
Span = 10	5, 7, 3, 1, 2, 9, 8, 4, 2, 6