Service-Related Conditions and Higher-Order Cognitive Processing in Military Veteran College Students

by

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ABSTRACT

Military veterans have a significantly higher incidence of mild traumatic brain injury (mTBI), depression, and Post-traumatic stress disorder (PTSD) compared to civilians. Military veterans also represent a rapidly growing subgroup of college students, due in part to the robust and financially incentivizing educational benefits under the Post-9/11 GI Bill. The overlapping cognitively impacting symptoms of service-related conditions combined with the underreporting of mTBI and psychiatric-related conditions, make accurate assessment of cognitive performance in military veterans challenging. Recent research findings provide conflicting information on cognitive performance patterns in military veterans. The purpose of this study was to determine whether service-related conditions and self-assessments predict performance on complex working memory and executive function tasks for military veteran college students. Sixty-one military veteran college students attending classes at Arizona State University campuses completed clinical neuropsychological tasks and experimental working memory and executive function tasks. The results revealed that a history of mTBI significantly predicted poorer performance in the areas of verbal working memory and decision-making. Depression significantly predicted poorer performance in executive function related to serial updating. In contrast, the commonly used clinical neuropsychological tasks were not sensitive service-related conditions including mTBI, PTSD, and depression. The differing performance patterns observed between the clinical tasks and the more complex experimental tasks support that researchers and clinicians should use tests that sufficiently tax verbal working memory and executive function when evaluating the subtle, higher-order cognitive deficits associated with mTBI and depression.

DEDICATION

I dedicate this work to the person who has dedicated so much to me, my husband, Scott Gallagher. With your unwavering support, I have the freedom and courage to conquer any challenge, overcome any obstacle, and attain any goal. Along this arduous academic path, riddled with obstacles, your strength and wisdom fortified my resolve and helped me achieve this goal. As in all aspects of life, you made every step easier, brighter, and so much better. I love you.

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TABLE OF CONTENTS

Page

LIST OF TABLES……………………………………………………………..……vi

LIST OF FIGURES…………………………………………………………...……vii

INTRODUCTION…………………………………………………………………...1

Veteran College Students……………………………………………………2

Service-Related Conditions…………………………………….……………3

Assessing Veteran Cognition………………………………………….….….6

CURRENT STUDY…………………………………………………….………..18

AIMS……………………………………………………………………..…………18

METHOD…………………………………………………………………………..20

Participants……………………………………………………….……………20

Stimuli……………………………………..……………………………..20

Procedure……………………………………..……………………..23

RESULTS…………………………………………………………………………..37

DISCUSSION………………………………………………………………………56

Limitations and Future Directions………………………………………………69

Conclusions……………………………………………………………………71

Page

REFERENCES……………………………………..…………………………….73

APPENDIX

A ONLINE VETERAN QUESTIONNAIRE.......………………….……..…85

B BECK DEPRESSION INVENTORY………………..……...…………..107

C BECK ANXIETY INVENTORY……………………………...…..……111

D COHEN PERCEIVED STRESS SCALE…………...………………………113

E LOGICAL MEMORY COMPLETE INFORMATION SCORING ……..…116

LIST OF TABLES

Table Page

1. Demographic Information for Veteran Control and mTBI Groups…………......21
2. Frequency of Service-Related Conditions for Veteran Control and mTBI Groups……………………………………………….......…….…………22
3. Correlation Coefficients for mTBI, PTSD, Inventory Scores, and Self-Ratings………………………...……………………………...…….............39
4. Mean Inventory Scores for Veteran Control and mTBI Groups..………………..41
5. Correlation Coefficients for Digit Span Scores…………………….....…..............42
6. Mean Scores for Digit Span, Trail Making, and Logical Memory tasks for Veteran Control and mTBI Groups…………………………………………...………..44
7. Correlation Coefficients for Trail Making Scores………………........................45
8. Correlation Coefficients Logical Memory Scores……………….………………47
9. Correlation Coefficients for Complex Span Scores……………………….………..48
10. Mean Scores for Complex Span, Iowa Gambling, and Serial Addition Tasks for Veteran Control and mTBI Groups…………………………..………………..50
11. Correlation Coefficients Iowa Gambling Task Scores….………………………51
12. Correlation Coefficients for Computerized Serial Addition Scores..……………55
13. Frequency of Males and Females with of PTSD, Depression, and Anxiety.....…60

LIST OF FIGURES

Figure Page

1. Trail Making Test Condition B Image…………………….…………………..26
2. Sequences for the Symmetry Span and Operation Span tasks…………………...29
3. Iowa Gambling Task Winning and Losing Feedback Images…………………...31
4. Sequence of Stimulus and Response for the Serial Addition Task………..……..33
5. Mean Block Scores for the Iowa Gambling Task………………..………………54
6. Mean Accuracy for the First and Second Half of the Serial Addition Task……..57

Service-Related Conditions and Higher-Order Cognitive Processing in Military Veteran College Students

Military veterans have a significantly higher incidence of mTBI, with estimates of 20-30% (Defense and Veterans Brain Injury Center, 2015) considered to be low estimates (Terrio et al., 2009). Although researchers across multiple fields have studied a variety of populations at risk for brain injury, such as professional and youth athletes, military service members are a subgroup of Americans who present with unique circumstances related to mTBI. These circumstances include cultural differences, the environment of injury, acute diagnosis and treatment, and high prevalence of concomitant conditions, such as Post Traumatic Stress Disorder (PTSD), depression, and anxiety. These differences specific to military veterans may adversely affect the validity of standard neuropsychological assessments for a variety of reasons, all of which contribute to the complexity of diagnosis and subsequent treatment planning related to mTBI symptoms.

In addition, history of mTBI has the potential to adversely affect future cognitive functioning (Covassin, Moran, & Wilhelm, 2013) and, in military veterans, may relate to the high rates of mental health difficulties (Macgregor, Dougherty, Morrison, Quinn, & Galarneau, 2011). Of particular interest is the impact of mTBI and commonly diagnosed service-related conditions on veterans as they transition from the military to novel, challenging civilian environments. Transitions from military service represent a period of significant change in terms of living situation, vocation, income, and social interactions. Separation from service and integration into civilian environments also typically require training, often in the form of post-secondary education.

Veteran College Students. Between 2014 and 2019, approximately a quarter of a million veterans will exit service each year, according to the Office of the Chairman of the Joint Chiefs of Staff, (Chairman's Office on Reintegration Report, 2014). With this exodus from service comes a significant transition from a highly structured environment with a clear chain of command and rules for communicating. As veterans seek vocational and educational opportunities, Post 9/11 GI Bill benefits provide an opportunity for income and housing while providing tuition and book funding along with the possibility of additional tax-free work-study income. In fact, between 2009, when the Post 9/11 GI Bill was established, and 2010 there was a 42% increase in veterans accessing their educational benefits (Department of Veterans Affairs, 2014). In 2011–2012 there were about 1.1 million military students enrolled in undergraduate education, up from 914,000 in 2007–08 (National Center for Education Statistics, 2016).

With a clear increased veteran presence on college campuses, the need to understand issues specific to military veterans and transition to college also increases. Veteran advantages and struggles related to academic success become clear as researchers gather data (Hammond, 2016). In his article in 1973, Olson reviewed the statistics demonstrating, not only the large numbers of veterans entering college after World War II but those documenting veteran academic "superiority." Some current researchers also support the idea that veterans represent a better prepared, more worldly, dedicated student (Ackerman, DiRamio, & Mitchell, 2008), and that they spend more time on coursework outside of class (Kim & Cole, 2013). A recent study published by the Student Veterans of America as part of the National Veteran Education Success Tracker (2017) report 72% academic success rates, significantly higher than previously reported.

However, this statistic is based on a combined percentage of students persisting in coursework, and students completing degrees. Persisting was defined as "enrolled between January 1st, 2015 and September 1st, 2015. If degree completion and attrition alone are examined, the numbers are not as robust.

These conflicting numbers related to student veteran success are not new and reflect a need to understand issues specific to military veteran college students. Some statistics report around a 51% college completion rate, lower than that of their non-veteran peers, which is approximately 59% completion (National Center for Education Statistics 2013). Some media sources cite the attenuation rate as high as 88% (Briggs, 2012). Despite the disparate numbers presented by government sources, media, and researchers, there are concrete issues that are unique to military veteran college students that may impact their academic success. Researchers have summarized the profiles of student veterans, including that they are older and more likely to be the first in their families to go to college (Fishback & Kirchner 2015). In addition to these documented demographic differences between military veteran college students and civilian college students, there is a multitude of other service-related factors that may impact college success and, therefore, warrant additional attention.

Service-Related Conditions. One such factor is in the environment of military service itself. Members of the military are part of a unique culture, one necessary for achieving difficult goals and overcoming seemingly insurmountable obstacles. All military branches embrace core values that include tenets, such as duty, honor, respect, courage (Kuehner, 2012). The term "military culture" is broadly used, but generally, military culture is defined by a unique vocabulary, rules, and belief systems (Reger et al., 2007). These belief systems include attitudes that seeking healthcare services is an indication of weakness. In fact, there is specific training and information developed for civilian healthcare providers, especially mental health care providers of military and veteran populations (e.g., Canfield & Weiss, 2015; Reger et al., 2007). These training programs are designed to help civilian healthcare providers understand and overcome the cultural barriers to care. Military culture particularly affects reporting of injuries in training and combat situations. Delay or complete lack of reporting is notable with concussions, a seemingly invisible injury where the symptoms may overlap with stigmatized mental health diagnoses (Cooper et al., 2015; Hoge et al., 2004; Hyatt et al., 2014).

Although delay and absence of reporting possible concussions occur in civilian settings (Hoffer, 2015), it is more likely to occur in the military (Hoge et al., 2004). This delay is particularly true in combat settings, likely due to the chaos of the battlefield, combined with the cultural belief that seeking healthcare is a sign of weakness. Military service members may also delay reporting their injuries because protocols in assessment and treatment may delay returning stateside, completing training, or exiting service (Rigg & Mooney, 2011). The long-term consequences of delaying report of injury include lack of immediate care for the mTBI, possibly exacerbating symptoms and placing the service member at risk for unremitting symptoms.

Whatever the basis, this delay in symptom reporting makes it difficult to discern relative contributions of mTBI or other factors to long-term symptom complaints.

Recollection of events surrounding the injury, the perception of injury severity, and temporal information related to symptom progression all might be lost. From a clinical perspective, it is difficult to plan a cognitive assessment and subsequent treatment when the underlying nature of the symptoms is unclear and undocumented. The service member may attribute symptoms to an event or injury that, in fact, may not be related to her or his actual symptoms.

Overlapping symptoms of depression, anxiety and PTSD and the frequent concomitance with mTBI, provides one of the largest hurdles in assessment (Karr et al., 2014; Lange et al., 2015). Estimates vary from 20% to approximately 44% of Operation Enduring Freedom (OEF) and Operation Iraq Freedom (OIF) veterans reportedly return home with PTSD symptoms along with depression and anxiety (Dolan et al., 2012). The relationship of mTBI and PTSD is especially significant for military veterans. Military veterans have a much higher incidence of both mTBI and PTSD than the civilian population, which is estimated at a twelve-month prevalence rate of 3.6% in the United States (National Institute of Health).

The co-occurrence of mTBI and PTSD diagnoses in military veterans is also significant. Some estimate that between 33%-39% of OIF/OEF/Operation New Dawn (OND) veterans with deployment-related mTBI also have PTSD (Lew et al., 2010). Some preliminary results from Azuma & Gallagher, (International Cognitive Communication Disorders Conference, 2017) indicate that military veteran college students report significantly higher rates of PTSD and combined PTSD and mTBI than their non-veteran peers. In that study out of 213 civilian participants, none reported combined diagnoses of

PTSD and mTBI, whereas nearly 29% of the veteran participants with mTBI also reported PTSD.

Researchers have examined PTSD and mTBI co-occurrence and the basis for ongoing symptom complaint**.** Some researchers have identified PTSD and depression as larger contributors to neuropsychological symptom complaints (Storzbach et al., 2015; Verfaellie et al., 2014), while others cite the combination of PTSD and mTBI as the significant contributor (Pineau et al., 2014). Still, other researchers show evidence that mTBI is the more significant contributor (Karr et al., 2014). If PTSD is untreated, cognitive deficits may be exaggerated by the overlapping symptoms of mTBI. Conversely, mTBI symptoms may go untreated if medical professionals assume the symptoms are due to PTSD sequelae. Obviously, there are different treatment approaches for the underlying causes, one requiring pharmacological and psychological treatment and the other requiring cognitive treatment. However, if both are contributing to cognitive deficits, it remains that those cognitive deficits should be addressed.

Assessing Veteran Cognition. Overall, for military veterans and service members, the unique nature of their environments and subsequent frequent exposure to situations and dangers that civilians may only encounter rarely may result in a number of injuries and illnesses that are difficult to assess. Clinicians and researchers evaluating the cognitive profiles of military service members and veterans are faced with difficult differential diagnoses most often without any clear medical documentation of injury. The existing, frequently used neuropsychological assessments were not created with an understanding of potential long-term consequences of mTBI. Nor were they created to consider such high rates of concomitant illnesses with overlapping symptoms. The frequent co-occurrences of mTBI and PTSD challenge the clinician and researcher charged with conducting cognitive assessments that will yield reliable, valid results. The confounding variables likely strongly contribute to the inconsistent neuropsychological test findings frequently reported in the literature (e.g., Karr et al., 2014; Pineau et al., 2014; Storzbach et al., 2015).

Many researchers report no long-term neuropsychological deficits associated with mTBI, (Storzbach et al., 2015). Some reports attribute the symptom complaints to a concomitant PTSD diagnosis (Lang et al., 2012; Verfaellie et al., 2014) and subsequently dismiss symptom self-report related to mTBI (Spencer et al., 2010; Verfaellie et al., 2014). However, using sensitive neuroimaging techniques, such as diffusion tensor imaging (DTI), Miller et al., (2016) showed that white matter changes in military service members with blast exposure was related to symptom complaint even when accounting for PTSD. Other researchers, such as Raskin et al., (2014) summarize multiple findings connecting symptom complaint to white matter changes in associated regions of interest using DTI. Recently some researchers have differentiated microstructural changes associated with mTBI from those associated with PTSD and corroborated those findings with self-report of symptoms (Hayes et al., 2015; Yeh et al., 2014). These studies provide evidence that medical professionals and researchers can reliably utilize self-report measures in the assessment and treatment process.

Reliable self-report measures have to be tailored to the unique circumstances of military servicemen and women and veterans. Creating a detailed survey is particularly important given the under-reporting of mTBI and other service-related conditions among military veterans. Developing comprehensive, valid questionnaires to document symptom patterns related to military-specific factors will help to validate symptoms associated with diagnosed and suspected mTBI. It will also provide researchers and clinicians with specific information related to mechanisms of injury in mTBI, individual differences of those sustaining mTBI, the environment of injury, and the number of exposures to blasts and other mechanisms causing mTBI. In their neuroimaging study, Hayes et al., 2015) have utilized a questionnaire in an interview format as part of their study, adapting it from the extensive interview developed by Fortier et al., (2014).

One component of a comprehensive questionnaire, well-established scales, and inventories, provide more standard measures for assessing depression, anxiety, and stress, symptoms commonly associated with military service members and veterans. The Beck Depression Inventory (BDI; Beck et al., 1961) has been shown to be a reliable instrument differentiating individuals with depression from those with no depression (Wang & Gorenstein, 2013). Similarly, the Beck Anxiety Inventory (BAI; Beck et al., 1996) has been shown to be a reliable assessment tool in clinical and non-clinical populations, including military veterans (Palmer et al., 2016). Finally, Cohen's Perceived Stress Scale (PSS; Cohen & Williamson, 1988), another commonly used, published scale has been widely used and well-studied across a variety of populations (e.g., Lavoie & Douglas, 2012; Ingram & Lichtenberg, 2016). However, static, published scales may be insufficient for identifying the sequelae associated with depression, anxiety, and stress that may be unique to a veteran population.

Researchers and clinicians must ask veterans and service members specific questions regarding the circumstances of diagnosed mTBI, the likelihood of an undiagnosed mTBI, and the presence of other service-related conditions, such as PTSD. Because veterans may not be familiar with mTBI symptoms, a symptom checklist (e.g., confusion, dizziness, nausea) and a situational checklist (e.g., experiencing a blast followed by a period of dizziness) may effectively elicit specific information about injuries and illnesses. This specificity may improve reliability over allowing the veteran just to conclude the source of his or her illness or injury based on the presence or absence of a formal diagnosis. It is also important to ask specific questions about symptoms, and circumstances surrounding injury so that the veteran or service member is not reliant on limited knowledge about mTBI or PTSD and a trained clinician or researcher can reliably determine the likelihood of a brain injury (Fortier et al., 2014).

Questionnaires should include scales to allow for self-assessments of their memory, attention, and related cognitive processes. Self-assessments should include questions comparing pre-injury to post-injury performance as well as pre-service to post-service performance. Finally, clinicians and researchers have to recognize that cognitive symptoms may not have been previously reported because of symptom subtlety that did not have a functional impact until the transition from the military into a new vocational, or academic setting. Therefore it is imperative that survey questions be specific about the environments in which the veteran is experiencing difficulties, and what type of environmental factors adversely impact specific cognitive skills. It is critical for researchers to develop meaningful questionnaires for veterans and establish validity across items within these questionnaires as part of a larger battery of cognitive assessment.

The battery of neuropsychological assessments has to be tailored as well. Although imaging studies have provided some basis for the reliability of symptom self-report, use of imaging techniques alone are insufficient for determining functional impairment. In fact, fMRI studies are often reliant on simple tasks as they are readily adaptable for use in imaging suites. Digit span tasks, for example, are frequently used in imaging studies, as was summarized by Lezak et al., (2012) showing changes in frontoparietal networks associated with mTBI during digit span tasks. However, many researchers, such as Pineau et al., (2014) and Verfaellie et al., (2014) have included digit span as an attention task for veterans with mTBI and consistently shown that it does not reveal deficits compared to controls. Variations of digit span tasks are part of several neuropsychological test batteries, such as the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS; Wechsler, 2009).

Like digit span, the Trail Making test is another widely used task found in commonly used neuropsychological test batteries, such as the Halstead-Reitan Neuropsychological Test Battery (HRNB; Reitan & Wolfson, 1993) and the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, and Kramer, 2001) as well as in research protocols (Gass, 2002; Kortte et al., 2002; Sanchez et al., 2009; Thaler et al., 2013). For this task, the test-taker is asked to complete Condition A by using a pencil to connect numbered circles in numerical order as quickly and accurately as possible without lifting the pencil. The subject is then asked to repeat the task in

Condition B by connecting circles labeled with both letters and numbers in order, but alternating between the letters and numbers, such as 1-A-2-B-3-C until the final letter is reached.

The Trail Making test is purported to be a measure of attentional control and set-shifting, visuomotor coordination (Armstrong et al., 2008; Jacobson et al., 2011). Test performance in Condition B is linked to working memory (Sanchez-Cubillo et al., 2009), and is used as a measure of a variety of aspects of executive function (Kane et al., 2004; Unsworth & Spillers, 2010). Robust normative data are available across populations (Giovagnoli, et al., 1996; Tombaugh et al., 2004), as are findings demonstrating sensitivity to performance differences in persons with TBI (Woods et al., 2015). However, findings related to military veterans with mTBI do not show performance differences compared to healthy controls (Gordon et al., 2011; Nelson et al., 2009). Despite these findings, the Trail Making Test continues to be used to assess veterans with complaints of unremitting symptoms related to mTBI and other service-related conditions (Kong et al., 2014; Troyanskaya, 2015).

Cognitive assessments of veterans and military service members with mTBI histories should include high-level cognitive tasks. Given the inconsistent neuropsychological findings related to mTBI, there is a possibility that test selection may play a role. In other words, researchers must select tasks that are most likely to be sensitive to subtle deficits associated with mTBI, which typically involve frontal lobe damage resulting in higher-level cognitive deficits. Associated functions of the frontal lobes include executive function, attention, and working memory. In their study, Pineau et al., (2014) selected tasks and tests hypothesized to differentiate performance patterns of individuals with mTBI, with PTSD, those with both, and controls matched to the mTBI and PTSD groups. Their results show that the individuals with combined mTBI and PTSD performed worse on long-term memory tasks than the other groups. When looking at performances on all tasks and tests, all three clinical groups did well on digit span and cancellation tasks.

Tasks must also be modified to replicate more closely the real world demands that may adversely impact memory, attention, and executive functions and scoring may need to be considered beyond the controlled scaled score to look for patterns of errors. For example, Geary et al., (2011) looked beyond total words recalled in a word learning task. They evaluated performance parameters related to strategies used during the task. Specifically, they considered semantic chunking strategies used by individuals with a history of mTBI compared to healthy controls. Their analysis of the task taken from a larger, standardized battery revealed that participants with mTBI histories performed differently than healthy controls in that they underused semantic chunking recall strategies. These differences were not readily apparent utilizing simple scoring methods.

Researchers and clinicians should include tasks that move from clean, quiet, surgically precise administration of standardized tests to more functional tests that task attentional control and working memory and better reflect the stressful, real-world environmental factors that may induce subtle, yet debilitating or at least vocationally limiting symptoms. Behavioral researchers have pointed to the impact on high-level language processing resulting from brain injuries impacting frontal lobe networks, a common factor in mTBI (Barwood & Murdoch, 2013). In addition to examining several other “multiple-demand” areas, imaging researchers (e.g., Fedorenko et al., 2013; Hagoort, 2014) add to the evidence that language areas contribute to a wide variety of cognitive tasks. Selection of verbal working memory tasks and verbal memory tasks requiring encoding and later retrieval may be sensitive to subtle, long-term deficits associated with mTBI.

The Logical Memory I (LM1) and Logical Memory II (LM2) subtests of the Wechsler Memory Scale – 4^{th} Edition (Wechsler, 2009) requires both immediate and delayed recall of verbal information. In the LM1 subtest, the participant is required to immediately retell a short story after hearing it produced by the clinician or researcher, and then immediately retell the second story after hearing it produced. The participant is not told that they will again tell the stories following an approximately 30-minute delay, but they are asked to do so in the LM2 subtest. Lezak (2013) summarizes findings that patients with TBI do show differences compared to healthy controls regarding the amount of information recalled. This type of complex narrative recall may be more sensitive to subtle deficits than word-list tasks.

Data from research presented at The American Speech-Language Hearing Association Convention, 2016 by Gallagher & Azuma, provide further evidence that LM1 and LM2 may be measures that are sensitive to subtle deficits associated with mTBI in military veterans. In that study, sixty-four military veteran college students were tested as part of a larger study. Based on self-reported information, twenty-two were identified as having a history of mTBI. Each participant administered the LM1 and LM2 subtests of the WMS-IV. For the LM1, the participant listened to two stories, both similar in length and complexity. After presenting each story, the participant was asked to retell the story using as many of the same words and providing as many details as possible. Following the immediate recall, there was a 20 to 30-minute delay, after which the participant was asked again to retell each story in detail. The LM1 and LM2 subtests are measures of immediate and delayed recall of semantically related verbal information.

To examine group differences in delayed and immediate recall of narrative information, a mixed-factor analysis of variance was completed with Delay (Immediate vs. Delayed) as the repeated-measures variable, Group (mTBI vs. no mTBI) as the between-subjects factor, and PTSD and Depression as covariates. The analysis revealed a significant main effect of Delay ($F(1,60) = 44.49$, $p < .001$, $\eta p^2 = .43$) and a significant Delay X Group interaction of ($F(1,60) = 5.8$, $p = .019$, $\eta p^2 =.088$). In the Immediate condition, the mTBI and no mTBI groups did not significantly differ in performance (t <1). However, in the Delayed condition, the mTBI group performed significantly worse than the no mTBI group ($t(62) = 1.97$, $p =.043$). This interaction remained significant even when PTSD, ($F(1, 60) = 2.57$, $p = .114$) and Depression, ($F(1, 60) = 2.70$, $p = .106$) and Depression were included as covariates.

The Iowa Gambling Task (IGT; Bechara et al., 1994) mirrors real-world decision-making and the need to employ outcome assessment and integration for making subsequent choices. It is a task which is used to measure decision-making and to assess the relationship between working memory and decision-making, (Cui et al., 2015; Bagneux et al., 2013) in non-clinical as well as clinical populations. For this computerized task, participants are shown four virtual decks of cards on a computer screen. They are told they can select cards, one at a time from any deck with the goal of "winning" as much virtual money as they can. Two of the decks are high-risk decks and will yield large amounts of money, but also will result in large amounts lost. Two decks are low-risk decks and will yield small amounts won, but also smaller amounts lost compared to the high-risk decks.

Researchers have shown that the task differentiates individuals with moderate TBI from controls (Cotrena et al., 2014), and also differentiates individuals with depression (Must et al., 2013). Given that the frontal lobes, an area largely associated with executive function, are frequently damaged in TBI, (Stuss, 2011), and the complex, real-world decision-making properties of the IGT, the task may elicit performance patterns that can identify subtle areas of deficits. However, IGT utility in military populations has been limited to risk-taking assessment and has been largely used in training environments, not in neuropsychological assessments. There is a lack of research regarding performance patterns in veterans with mTBI or PTSD. In fact, this task has not been sufficiently studied in individuals with mild traumatic brain injury in any subgroup.

A working memory task not frequently used given its stress-inducing properties, the Paced Auditory-Serial Addition Test-Revised (PASAT-R; Gronwall, 1977), may be a useful working memory task for military veterans with mTBI and PTSD. The task has a long and short form. It requires the participant to serially add a number to the preceding number in an orally presented list of numbers. For example, if the participant sees the number "02," followed by "05," the participant must type "07." When shown the next number, “04,” the participant must type, “09.” In their study, Vanderploeg et al., (2005) examined data from a modification of this task as part of a larger battery of assessments of Vietnam veterans with mTBI histories. The researchers allowed participants to discontinue participation in subsequent trials of the task if their frustration levels were too high. Statistical analysis of task performance showed that only rate of task discontinuation was significantly different for veterans with mTBI histories (compared to veterans without mTBI, but motor vehicle accident history and healthy controls). Within the test battery, only this measure and proactive interference rates on another task showed differences for veterans with mTBI history.

The Vanderploeg et al., (2005) study analyzed data collected in 1988, some 18 plus years post-onset mTBI. These men, when interviewed, likely had a different understanding of mTBI compared to today’s criteria and did not consider the now common blast-injury. However, if the serial addition task was replicated with current OEF/OIF/ND veterans who recently separated from service with fewer years post-onset mTBI, it may provide valuable information about working memory, as well as attention. This task is reportedly frustrating but sensitive to post-concussive symptoms, (Lezak et al., 2012). The element of frustration may result in some confounds, specifically with the impact of anxiety on memory performance. However, it can be used in coordination of anxiety self-ratings related to task performance as an additional basis for analysis. The serial addition task is challenging enough, tapping updating and inhibition under time pressure, that it may show subtle cognitive difficulties. In modifying the task to allow participants to skip items, it may provide additional insight into attention, vigilance, and performance related to self-reported anxiety ratings.

There are a number of working memory span task widely used in research settings, the Operation Span as described by Unsworth et al., (2005) show strong reliability and validity even across a variety of task variations. Complex span tasks differ from simple span tasks, such as digit span tasks, in that they include a secondary task versus just item recall. In a review by Conway et al., (2005), they cite ample evidence for the validity of complex span tasks, including operation span. They further provide evidence that these tasks measure the construct of attentional control, it is a stable measure, and it correlates highly with a variety of other skills. While many research and clinical evaluations utilize simple span tasks with veterans with mTBI, few utilize complex span tasks. Use of both a verbal and non-verbal complex span task with military veterans may elucidate performance patterns useful in identifying subtle long-term deficits associated with mTBI and PTSD.

In the computerized operation span task, participants are asked to quickly decide whether an arithmetic sentence appearing on the screen is accurate or inaccurate. A second screen then appears showing a letter. After three to six alternating sequences of arithmetic sentences and letters, the participant is asked to recall the letters they saw in the order they appeared. The non-verbal symmetry span task has been used by researchers to study working memory without involving verbal processing (Kane et al. 2004; Redick et al. 2012). The non-verbal symmetry span task also requires participants to alternate between two tasks. They are asked to quickly decide whether a design is symmetrical about the vertical axis. They then see a screen with a red square on a 4x4 grid. After three to six alternating designs and red squares, the participant is asked to recall the squares they saw, in the order in which they appeared. In their work, Unsworth

& Engle, (2007) report the use of complex span tasks in measuring higher-level skills, such as “executive attention,” where both attention and memory skills are required. In these studies, researchers note the high test-retest reliability of these tasks and ease of replication with these automated tasks. This task is also predictive of fluid intelligence (Unsworth et al., 2005) and reading ability (Turner & Engle, 1989). Therefore performance patterns on these complex span tasks may offer insights into implications for academic and vocational success.

The Current Study. The purpose of this study was to determine whether service-related conditions and self-assessments predict performance on complex working memory and executive function tasks for military veteran college students. There were multiple specific aims and hypotheses. The first specific aim was to determine whether mTBI and PTSD predict anxiety, depression, and stress severities in military veteran college students. Given the overlap in symptoms and high rate of co-occurrence for all of these conditions, (e.g., Karr et al., 2014), it was hypothesized that mTBI history and PTSD would predict higher levels of anxiety, depression, and stress.

The second aim was to determine whether service-related conditions, mTBI, PTSD, anxiety, depression, or stress predict self-rating of overall memory and attention skills. Given the frequency of occurrence of these conditions in veterans, it is important to examine the relationship between these conditions and self-assessment of cognition. Based on the overlap in cognitively related symptoms in mTBI, PTSD, anxiety, depression, and stress, it was anticipated that these conditions would predict self-assessed memory and attention difficulties.

The Third aim was to evaluate whether service-related conditions and self-assessments predict performance on commonly used neuropsychological tasks. Based on previous research findings related to military veterans' performance on these tasks, (e.g., Pineau et al., 2014), it was expected that mTBI, PTSD, Depression, Anxiety, Stress, self-rated memory and self-rated attention difficulties would not predict performance on commonly used clinical neuropsychological tasks.

The fourth aim was to determine whether a history of mTBI, PTSD, depression, anxiety, and stress, predict poorer performance on complex working memory and executive function tasks. Service-related conditions may result in subtle deficits that may not be identified using common clinical neuropsychological tasks. Complex tasks and tasks that more closely mirror real-world demands may be more sensitive to those subtle deficits, (Cotrena et al., 2014). Therefore, it was hypothesized that service-related conditions would predict poorer performance on complex working memory and executive function tasks.

The fifth and final aim was to determine whether self-rated memory and self-rated attention difficulties predict poorer performance on complex working memory and executive function tasks. Recent imaging studies provide evidence corroborating symptom report in military veterans, (Raskin et al., 2014). It is reasonable that behavioral measures may also provide this corroboration if the tasks are more complex and measure higher-order cognitive processes. It was hypothesized that self-reported memory and attention difficulties would predict poorer performance on complex working memory and executive function tasks.

Method

The protocol for this study has been approved by the Arizona State University Institutional Review Board for STUDY00001110.

Participants. Participants completing this study included sixty-one military veteran undergraduate college students attending classes at one of the Arizona State University campuses. Veterans were recruited through the Pat Tillman Veterans Center, the East Valley Veterans Education Center, and social media. Participants completed electronic informed consent prior to participating and were offered two free movie ticket vouchers as compensation for participation. A subset of participants reported a history of mTBI; they were included in the mTBI group. Criteria for inclusion in the mTBI group was determined by responses to questions regarding diagnosed mTBI, as well as the signs and symptoms of suspected mTBI based on overlapping criteria from the Mayo Classification System for Traumatic Brain Injury Severity (Malec et al., 2008) and the American Congress of Rehabilitative Medicine (ACRM) criteria.

Study inclusion criteria also required normal or corrected-to-normal vision and hearing. See Table 1 for a summary of demographic information for both the healthy control veterans (no mTBI history) and veterans with mTBI groups. No Participants reported a history of stroke and no speech differences or motor impairments were reported by participants or observed in any participants. Summary of frequencies of reported service-related conditions and related symptoms are summarized in Table 2.

Stimuli. A 107-question, online questionnaire (Appendix A) was used to gather demographic information, educational history, military service history, medical history,

Table 1

Demographic Information for Veteran Control and mTBI Groups

	Control Veterans (n=36)	Veterans with mTBI (n=22)	Group Difference
Mean Age in Years (SD)	28.44 (6.40)	30.95 (6.8)	*t*=1.41, *p*=.163
Mean College GPA (SD)	3.28 (.45)	3.27 (.41)	*t*<1
Mean College Credits Earned (SD)	82.33 (58.34)	77.38 (63.35)	*t*<1
Mean # of Months Before First College Course (SD)	24.19 (29.71)	38.68 (40.11)	*t*=1.58, *p*=.121

Note. GPA = Grade Point Average; # Months Before First College Course: Number of months between high school graduation/GED and enrollment in first college class

Table 2

Frequency of Veterans Reporting Post-Traumatic Stress Disorder, Memory Difficulties, Stress, Anxiety, and Depression for Veteran Control and mTBI Groups (Percentages in Parentheses)

	Control Veterans (n=36)	Veterans with mTBI (n=22)	Group Differences
PTSD	3 (8.3%)	12 (54.5%)	χ^2= 15.21, *p*<.001**
Memory Difficulty	14 (38.9%)	15 (68.2%)	χ^2= 4.69, *p*=.030*
Attention Difficulty	17 (47%)	16 (72.7%)	χ^2=3.62, *p*=.057
Stress	20 (55.6%)	12 (54.5%)	χ^2<1
Anxiety	11 (30.6%)	4 (18.2%)	χ^2=1.09, *p*=.296
Depression	7 (19.4%)	6 (27.3%)	χ^2<1

Note. PTSD = Post-Traumatic Stress Disorder; Significant Stress = Perceived Stress Scale score above 13; Significant Anxiety = Beck Anxiety Inventory score above 15; Significant Depression = Beck Depression Inventory score above 20.

mTBI history, and self-rating of memory, attention, and anxiety. Participants responded to questions regarding age, gender, culture, primary and secondary languages, parental education and vocation. They provided information about high school grade point average, as well as pre-service diagnosed learning disabilities. Questions related to mTBI history asked about diagnosis, circumstances surrounding any suspected or diagnosed mTBI, and symptoms immediately occurring and unremitting. Participants were asked to self-report diagnosed PTSD, including information regarding diagnosis timeframe and the entity providing the diagnosis. They were asked about medications, history of stroke, and any other injuries or medical diagnoses.

Participants were asked to self-rate overall memory, attention, and anxiety using a 5-point Likert-type scale, (e.g., "My OVERALL memory is much better, slightly better, the same as, slightly worse, far worse than other people my age."). The 21 questions from the Beck Depression Inventory (Beck et al., 1961) were embedded in the online questionnaire. The whole questionnaire took approximately thirty minutes to complete. Frequencies of reported services-related conditions along with self-reported memory, attention, and anxiety difficulties are summarized in Table 2.

Procedure. Prior to in-person testing each veteran participant provided electronic consent and completed the online questionnaire. In-person testing consisted of both Computerized tasks and paper and pencil inventories. In-person testing required approximately two hours to complete. All participants were administered all tasks.

Inventories. The 21-item Beck Depression Inventory (BDI; Appendix B) was integrated into the veteran on-line questionnaire and comprised the final 21 questionnaire items. Each item was written in the form of a statement, was rated by the participant as 0 = Not at all; 1 = Mildly; 2 = Moderately; 3 = Severely. Participants were instructed to rate each statement as it related to experiences over the previous month.

The 21-item Beck Anxiety Inventory (BAI; Appendix C) was provided in paper format during the in-person testing. Participants were instructed to rate anxiety symptoms as they have experienced over the last month. The 4-point rating scale asked participants to rate symptoms according to the following scale: 0 = not at all, 1 = Mildly, but it didn't bother me much, 2 = Moderately, it wasn't pleasant at times, and 3 = Severely, it bothered me a lot.

The Cohen Perceived Stress Scale (PSS; Appendix D) was also administered in paper format during in-person testing. Participants were instructed to rate stress symptoms as they have occurred over the past month according to the following five-point scale: 0 = Never; 1 = Almost Never; 2 = Sometimes; 3 = Fairly Often; 4 = Very Often. The two paper scales took a total of ten minutes to complete.

Clinical Tasks.

Simple Span. Digit Span Forward and Backward are simple span measures. It requires the participant to repeat an increasing sequence of numbers, first in the same order as presented, and then in the reverse order. This task was administered by computer using The Psychology Experiment Building Language (PEBL) version 0.14 (Meuller & Piper, 2014). Numbers were presented one at a time on the computer screen as well as auditorily through headphones. Sequences started with three numbers and increased until the participant missed two consecutive items within a span set. The computer program presented two trials for each span length. The two simple span tasks took approximately ten minutes to complete.

Attention. A computerized version of the Trail Making Test, containing conditions A (numbers only) and B (alternating numbers and letters), was administered using PEBL version 0.14 (Meuller & Piper, 2014). Performance on the computerized version of this task has been shown to be consistent with the paper version across a large age span (Piper et al., 2012). For the "A" condition of this task, participants were asked to use a mouse to quickly and accurately connect the circles by clicking on each of them in numerical order. For the "B" condition of this task, participants were asked to click on circles in alternating numerical and alphabetical order. For example, the participant started with the circle marked "1" and then clicked on the circle marked "A," then "2" then "B" until all circles were connected. Figure 1 shows condition B of this task. Participants completed practice trials in both the A and B conditions before progressing to the task. The computer program randomly generated tests in both conditions.

Episodic Memory. Participants completed an adapted, computerized version of the Logical Memory I (LM1) subtest of the Wechsler Memory Scales – IV (WMS-IV; Wechsler 2009). The LM1 subtest tests immediate recall of narrative information. Seated in front of a computer, participants watched and listened to (via headphones) a video recording of a person telling the first story. Immediately following the story, the participant was asked to retell the story "in as much detail as possible." The participant repeated this process with the second story. Both story retellings were recorded using

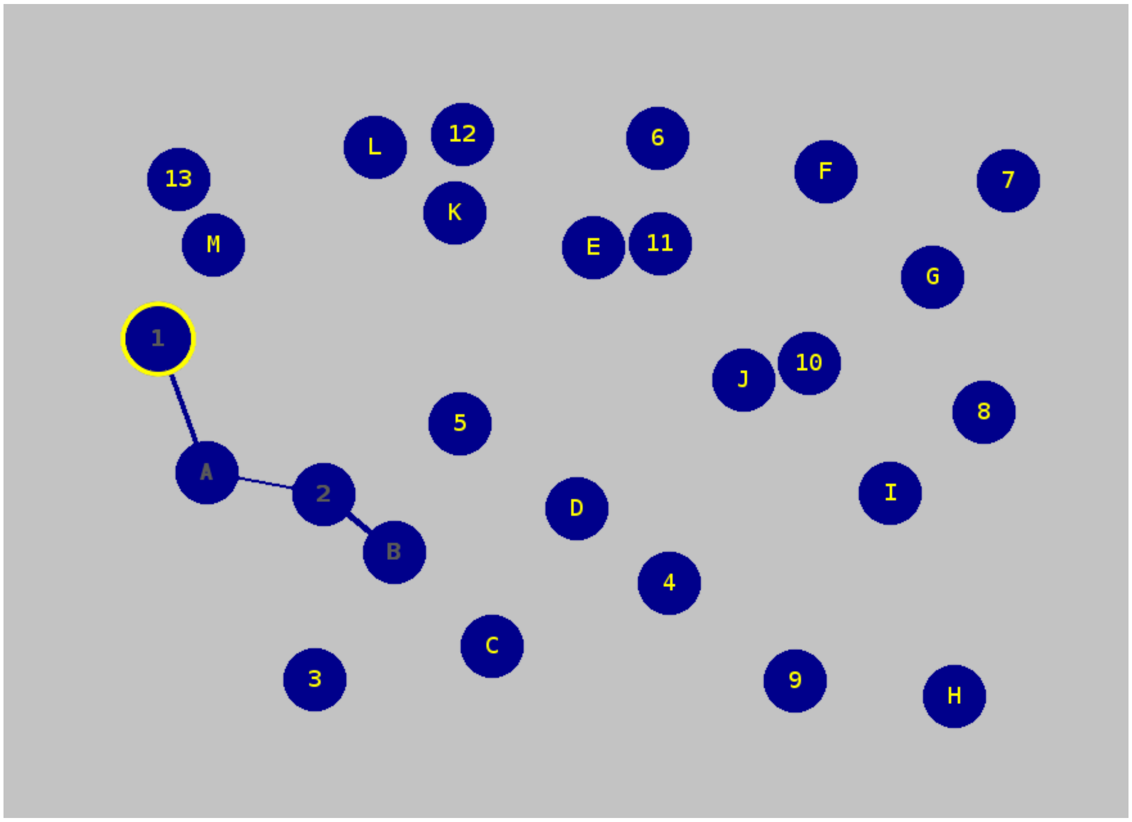

Figure 1. Screen image of the alternating numbers and letters procedure comprising Condition B in the Trail Making Task from The Psychology Experiment Building Language (PEBL) version 0.14 (Meuller & Piper, 2014).

Audacity® 2.1.2. Participants were not advised that they would be asked to retell the stories again after a 20-30-minute delay. During this delay, a working memory task and the paper versions of the BAI and PSS were administered. Once 20-30 minutes elapsed since completing LM1, the Logical Memory II (LM2) subtest of the Wechsler Memory Scales – IV (WMS-IV; Wechsler 2009) was administered per test manual instructions. The participant was asked, "Do you remember the two stories you heard earlier? I want you to tell them back to me now in as much detail as possible." Responses were also recorded using Audacity® version 2.1.2. The two LM subtests took a total of five minutes to complete excluding the delay.

Higher-Order Tasks.

Complex Span. The non-verbal symmetry span test (Kane et al., 2004) is a computerized working memory test. Stimuli were presented electronically using the E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). In the task, written instructions were presented on the computer screen. Practice trials were completed for each condition, separately, then in combination. For this task, participants first viewed a black and white geometrical image. They had 4000 ms to click on the screen and then select either "yes," to indicate the design was symmetrical about the vertical axis, or "no" to indicate it was not. After entering their judgment regarding image symmetry, a red square appeared on a 4x4 grid for 1000ms on the screen followed by another black and white design. Following two to six sets of alternating symmetry judgment/square recall sequences, participants were shown a blank grid and asked to select the squares where red squares had appeared, in the order they appeared. They were directed to click a box labeled “blank” if they could not remember the location of a particular red square to preserve the response order. They were given accuracy-specific feedback after each set and directed to maintain 85% accuracy for symmetry judgments. Span lengths were presented in random order with two trials for each span length. This task took approximately ten minutes to complete.

The operation span task is a computerized experimental task utilized to measure complex verbal working memory (Turner & Engle, 1989). Stimuli were presented electronically using the E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). Participants were given written instructions presented on the computer screen. They were given an opportunity to practice each component of the task separately and then in combination. Participants were shown a mathematical problem, such as “(2 * 3) – 1 = ?.” On the following screen, the participant was shown a possible answer to the math problem and was asked to choose “true” or “false” to indicate whether the mathematical sentence was solved accurately. The participant was then shown an upper-case letter of the English alphabet for 1000ms, and then another mathematical problem. Following two to six sets of alternating math problem/letters, a table containing 12 letters appeared on the screen. The participant was asked to select the letters that were shown, in the order they were seen. Accuracy-specific feedback was shown on the screen. Participants were instructed to be fast and to maintain 85% accuracy for judging the mathematical problems. This task took approximately ten minutes to complete. Figure 2 summarizes complex span task sequences.

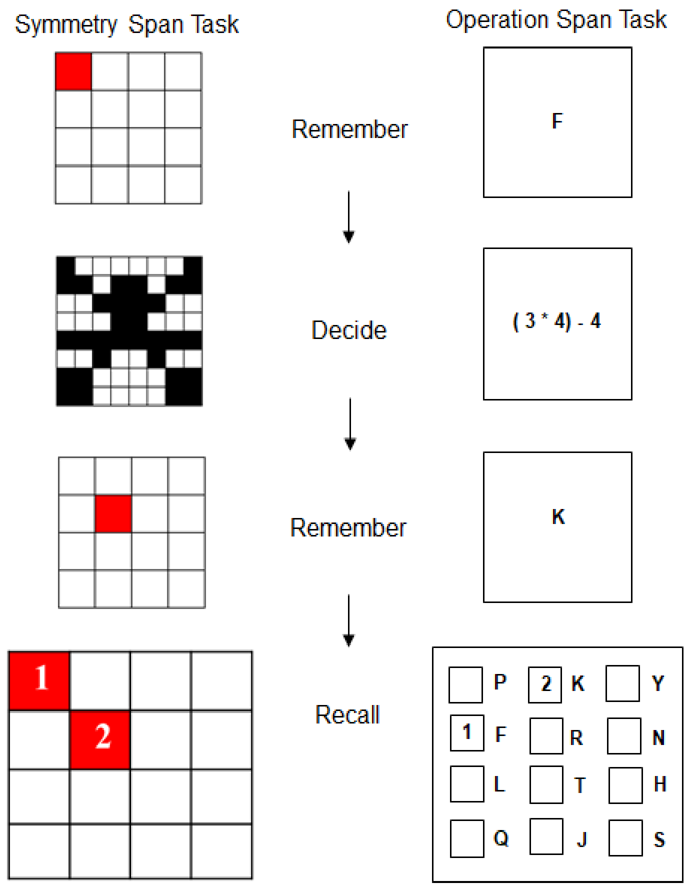

Figure 2. Sequence of Stimuli for the Symmetry Span and Operation Span Tasks.

Decision Making & Executive Function. The Iowa Gambling Task requires participants to evaluate probable outcomes and make decisions based on those outcomes to achieve "rewards." This sequential learning task was presented on a computer using PEBL version 0.14 (Meuller & Piper, 2014). Participants were presented with four virtual decks, labeled "A," "B," "C," and "D." They were instructed to select one deck at a time. They were informed that sometimes they would win, and sometimes they would win and lose, and that the amounts won or lost would vary. They were told they could switch decks anytime and as often as they like with the goal of winning "as much money as possible." Participants were given feedback in the form of virtual money won or lost along with sounds associated with winning and losing and either a happy face for wins, or a sad face for losses. A horizontal progress bar at the top of the screen tracked overall win/loss amounts. Figure 3 shows winning and losing screens for the IGT. In this task, decks "A" and "B" are high-risk decks and will yield larger winnings and larger losses than the low-risk decks, "C" and "D." The decks are also divided into high and low frequency of loss decks. Decks "A" and "C" lose more often than decks "B" and "D." This task took approximately ten minutes to complete.

The computerized visual serial addition task is to assess attention control and speed of processing (Tombaugh, T.N., 2006). The task requires the participant to serially add a number to the preceding number in a visually presented sequence of numbers. This task was adapted for computer presentation using E-Prime software version 2.0 (Psychology Software Tools, Pittsburgh, PA). In response to the first number presented, the participant typed that number. After the second number was presented, the participant

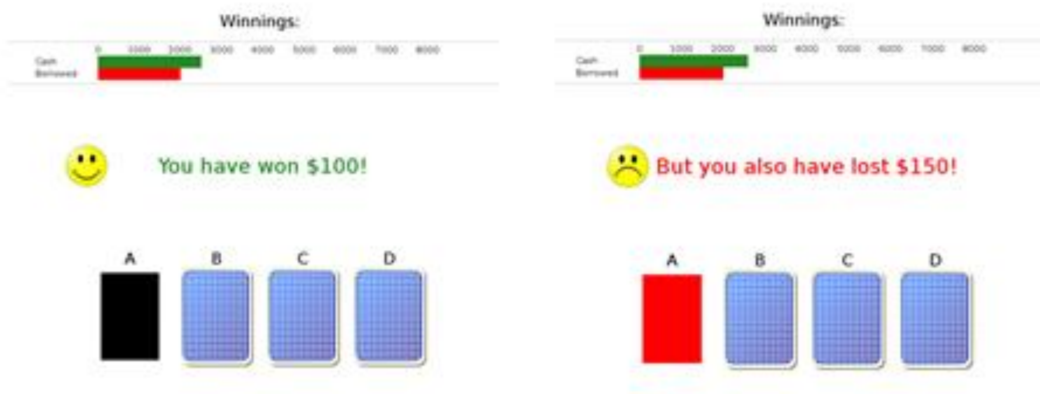

Figure 3. Iowa Gambling Task winning and losing screen images from The Psychology Experiment Building Language (PEBL) version 0.14 (Meuller & Piper, 2014).

typed the sum of the first two numbers. For example, if the number 02 was presented first, the participant typed “02.” If the second number presented was 06, the participant typed “08,” the sum of the first and second stimulus items. If the third number presented was 05, the participant typed “11,” the sum of the second and third stimulus items. In other words, the participant did not add presented numbers to the previous sum, but to the previous stimulus item. Participants were required to enter a leading “0” for single digit sums. Figure 4 shows the sequence of stimulus and response screens. Participants typed responses and were given accuracy and timing specific feedback only when inaccurate or failed to respond within four seconds. They were not given feedback for correct or timely responses. They were permitted to skip trials by typing 00 at any time and as many times as they chose. Participants completed 100 trials. This task took approximately ten minutes to complete.

Scoring.

Self-Ratings. Memory Self-Ratings were entered by participants according to the following scale: 1= My memory is much worse than other people my age; 2= My memory is somewhat worse than other people my age; 3= My memory is about the same as other people my age; 4= My memory is somewhat better than other people my age; 5= My memory is much better than other people my age.

Attention Self-Rating for overall attention in normal distractions (e.g. people talking nearby or a television on in the room) were entered by participants according to the following scale: 1= I usually experience no problems with attending with such distractions; 2= I usually experience minor difficulty attending with such distractions;

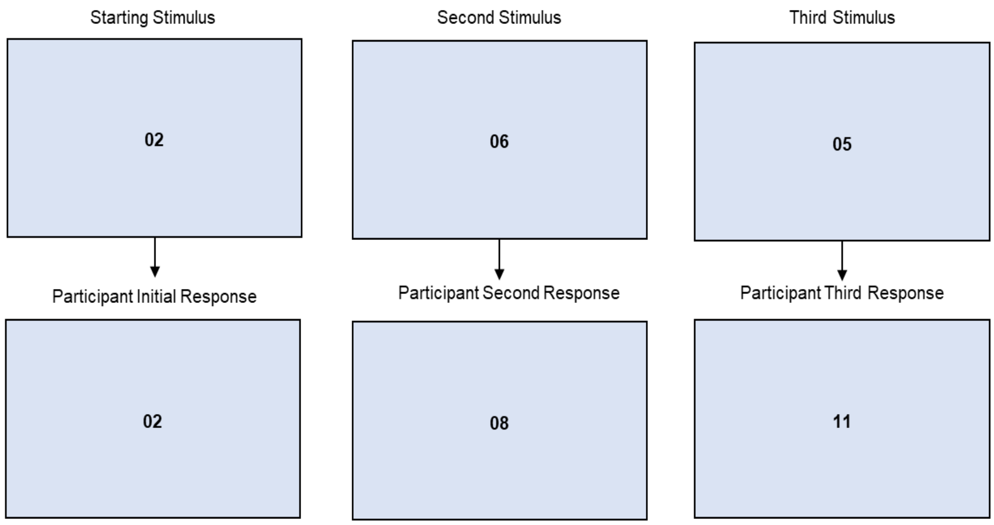

Figure 4. Sequence of stimulus and responses for the Computerized Visual Serial Additon Task.

3= I usually experience moderate difficulty attending with such distractions; 4= I usually experience severe difficulty attending with such distractions.

Inventories. All three inventories (BDI, BAI, and PSS) were all scored by totaling ratings selected by participants for each item per inventory instructions. For the BDI, a minimum score of zero and a maximum score of sixty-three was possible, with a maximum of three points possible for each item. Severity of depression was based on the total score was defined in the protocol as follows: 17-20 = Borderline; 21-30 = Moderate; 31-40 = Severe; Over 40 = Extreme.

For each item in the BAI, the following scale was applied: Not At All = 0; Mildly = 1; Moderately = 2; Severely = 3. The lowest possible score was zero and highest possible total for the inventory was sixty-three. Scores below 8 indicate minimal anxiety. Per the inventory protocol, scores ranging from 8-15 were considered mild, 16-25 moderate, and 26-63 severe.

For the PSS, four points were possible for each of the ten items. Each item was rated on a 5-point scale ranging from never (0) to almost always (4), with higher scores indicating higher stress. For the four positively worded items inverse scoring was applied with lower scores indicating more perceived stress. According to scale instructions, scores of twenty or higher were considered "high stress."

Clinical Tasks.

Simple Span. Digits Forward and Digits Backward Span Scores were calculated based on highest number of digits a participant accurately recalled before missing two consecutive items within a span set. This scoring approach is commonly utilized in a wide variety of test batteries, such as in the Repeatable Battery for the Assessment of Neuropsychological Status (Randolph, 1988), the Wechsler Adult Intelligence Scales (Wechsler, 2009). Calculations for span score were made automatically by PEBL.

Attention. Based on previous research examining speed of processing in the Trail Making Test (Nelson et al., 2009; Thaler et al., 2013), Total Number Speed Scores were calculated based on the sum of response times for all four trials of each of the Condition A tasks, numeric-only. A Total Alternating Speed Score was calculated based on total response time for all four switching (number-letter) trials, representing Condition B. Accuracy measures have also been found to be sensitive to deficits associated with brain injuries (Mahurin et al., 2006; Stuss et al., 2001) Number Accuracy Scores were calculated based on average click/hit rates for all four trials of each of the Condition A tasks. An Alternating Accuracy Score was calculated based on the average mouse click/target-hit ratio of all four trials of the Condition B task. Finally a frequently used derived score, (Lamberty, Putnam, Chatel, Bieliauskas, & Adams, 1994; Martin, Hoffmann, & Donders, 2003), the Alternating-Number Speed Difference Score was calculated by subtracting the total completion time for all four trials of Condition A from the total completion time for all four trials of Condition B.

Episodic Memory. Logical Memory 1 and 2 recorded responses were transcribed by two independent transcribers. Two independent scorers trained in the procedures of the WMS-IV and the novel scoring procedures scored transcribed story retells.

Transcriptions were scored for total number of Correct Ideas and Total Words Produced. Correct Ideas were calculated by adding the total number of individual facts recalled from the story. Facts were separated into specific informational units for scoring (Appendix E details scoring elements). For example, the information included in this sample “she had four small children, the rent was due, and they had not eaten for two days” was categorized into the following individual idea units: 1) four, 2) children, 3) rent was due, 4) had not eaten, 5) two, 6) days. There was 93.3% agreement between the two scorers, with discrepancies resolved by the researcher. Total Words Produced were calculated by adding the story-relevant words. Words related to the story, but not part of the plot, such as, “Her name started with a…” were counted. Words unrelated to the story, such as “That is all I can remember,” were not included in the calculation. Finally, a raw score was also calculated based on the standardized methods according to the WMS-IV manual.

Higher-Order Tasks.

Complex Span. A Total Score was calculated for the Symmetry Span task by totaling the number of correct items recalled across all trials, with a maximum possible score of 24. The Operation Span Task was also scored by tabulating accurate recall for all items across span sets for a maximum possible score of 30. For both the Symmetry Span and Operation Span tasks, E-Prime 3.0 software (Psychology Software Tools, Pittsburgh, PA) automatically calculated total span scores.

Decision Making & Executive Function. Based on conventional scoring of the

Iowa Gambling Task (Bechara, 2007; Bagneux et al., 2013; Cotrena et al., 2014; Brenner et al., 2015), the 100-item computerized IGT was scored for number of advantageous deck selections. An Advantageous Deck Total Score was calculated by subtracting the total number of selections of high-risk decks from the total number of selections of low-risk decks [(C+D)-(A+B)] for trials 21 through 100.

To obtain a measure of participants' Sensitivity to Loss Frequency, the difference between the number of choices from the low-loss (*B* and *D*) and the high-loss (*A* and *C*) frequency decks (B+D) – (A+C) was calculated for trials twenty-one through one hundred to obtain a Total Sensitivity to Loss Frequency Score, (Stocco et al., 2009). In the IGT, the first 20 responses represent a learning phase of the task where responses are highly variable, and not indicative of goal-directed responding. Therefore, the first twenty responses were not analyzed for either the Advantageous Deck Score and the Sensitivity to Loss Frequency Score. Finally, a measure of deck preference was obtained by calculating the total number of selections made for each deck across all 100 trials.

For the Computerized Visual Serial Addition Task, a Total Proportion Correct Score was obtained based on the number of correct responses across all 100 trials. A Speed Error Score was obtained by totaling the number of trials where no response was entered. Response timing and each response accuracy were scored automatically by the E Prime program.

Results

Two participants were excluded due to missing demographic and questionnaire data. One participant was excluded due to self-reported limited English proficiency. Fifty-eight participants were included in the analysis.

Inventory Scores. To examine the relationship between inventory scores (BAI, BDI, and PSS) and service-related conditions (mTBI, PTSD), correlational analyses were conducted. See Table 3 for correlational analyses results for inventory scores, service-related conditions, and self-ratings.

With BDI as the dependent variable, the significantly correlated service-related condition (PTSD) and the marginally significantly correlated service-related condition (mTBI) were entered as predictor variables in a multiple linear regression analysis. The regression model was significant, (R^2_{adj} = .222, F (2,55) = 9.12, p < 001). The analysis showed that PTSD significantly predicted BDI score, (β = .499, t = 3.67, p = .001). Veterans with PTSD had more severe depression than veterans with no PTSD diagnosis. History of mTBI did not significantly predict BDI score, (β = -.001, t <1).

Self-Ratings. With Memory Self-Rating as the dependent variable, the significantly correlated variables, (BAI, BDI) and the marginally correlated variables (PTSD, mTBI) were entered as predictor variables in a multiple linear regression analysis. The regression model was significant, (R^2_{adj} = .236, F (4,53) = 4.53, p= 002). The analysis showed that BDI scores significantly predicted Memory Self-Rating, (β = -.6.20, t = -3.475, p = .001). Veterans with more severe depression rated their memory as worse. None of the other variables, BAI, (β = .035, t <1), PTSD, (β = .093, t <1), mTBI, (β = .120, t <1), or PSS, (β = .152, t = -1.09, p = .278) were significant predictors of Memory Self-Ratings.

Table 3

Correlation Coefficients and p values for mTBI, PTSD, Inventory Scores, and Self-Ratings (n = 58)

	mTBI	PTSD	BDI	BAI	PSS	Memory Rating
PTSD	.512** (<.001)					
BDI	.255 (.053)	**.499**** **(<.001)**				
BAI	-.021 (.878)	**.297*** **(.023)**	.657** (<.001)			
PSS	-.140 (.296)	.110 (.413)	.449** (<.001)	483** (<.001)		
Memory Rating	-.253 (.055)	-.251 (.057)	**-.513**** **(<.001)**	**-.269 *** **(.041)**	-.082 (.541)	
Attention Rating	.148 (.268)	.236 (.074)	**.378*** **(.003)**	**.366**** **(.005)**	**.299*** **(.023)**	-.326* (.012)

Note. mTBI = Mild Traumatic Brain Injury; PTSD = Post Traumatic Stress Disorder; BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory; PSS = Perceived Stress Scale.
** = Correlation is significant at the .01 level (2-tailed); * = Correlation is significant at the .05 level (2-tailed)

With Attention Self-Rating as the dependent variable, the significantly correlated variables, (BAI, BDI, and PSS), and the marginally correlated variable, (PTSD) were entered as predictor variables in a multiple linear regression analysis. The regression model was significant, (R^2_{adj} = .123, F (4,53) = 2.99, p =.027). The analysis showed that BAI, (β = .167, t <1), BDI, (β = .162, t <1), PSS, (β = .136, t <1), and PTSD, (β = .091, t <1), did not significantly predicted Attention Self-Rating. Means and standard deviations of self-ratings and inventory scores are shown in Table 4.

Digit Span Tasks. Correlational analyses were conducted to examine the relationship between disorders/self-rated difficulties (mTBI, PTSD, BDI, BAI, PSS, Memory Rating, Attention Rating) and Performance on the Digit Span Tasks (Digits Forward and Digits Backward). Table 5 summarizes digit span correlational analyses results.

The two variables that were significantly correlated with Digits Forward (BAI Score and Attention Self-Rating) were entered as predictor variables in a multiple linear regression. The model was significant (R^2_{adj} = .157, F (2,55) = 6.29, p = .003). The analysis showed that BAI Score significantly predicted Digits Forward Span Score, (β = -.280, t = -2.14, p = .037). More severe anxiety levels significantly predicted lower Digits Forward Span Scores. Attention Self-Rating marginally predicted Digits Forward Span Scores, (β = -.241, t = -1.85, p = .070). Mean scores and standard deviations for all clinical tasks are listed in Table 6.

Computerized Trail Making Test. Electronic raw data for nine participants were erroneously labeled and, therefore, could not be matched to relevant demographic data.

Table 4

Mean Scores (Standard Deviations in Parentheses) of Perceived Stress Scale, Beck Anxiety Inventory, and Beck Depression Inventory for Veteran Control and mTBI Groups

	Control Veterans (n = 36)	Veterans with mTBI (n = 22)
Perceived Stress Scale	17.39 (8.58)	15.09 (7.07)
Beck Anxiety Inventory	13.78 (10.32)	13.36 (9.25)
Beck Depression Inventory	11.78 (10.64)	17.09 (8.67)
Memory Self-Rating	2.86 (.87)	2.36 (1.05)
Attention Self-Rating	2.56 (.99)	2.82 (.59)

Table 5

Correlation Coefficients and p values for mTBI, PTSD, Self-Assessments and Digit Span Scores (n = 58)

	mTBI	PTSD	BDI	BAI	PSS	Memory Rating	Attention Rating	Digits Forward
Digits Forward	.026 (.845)	-.034 (.803)	-232 (.079)	**-.368**** **(.004)**	-.179 (.180)	.206 (.121)	**-.344**** **(.008)**	–
Digits Reversed	-.222 (.097)	-.182 (.175)	-.160 (.234)	-.090 (.507)	.058 (.666)	.201 (.134)	.040 (.770)	.311* (.019)

Note. mTBI = Mild Traumatic Brain Injury; PTSD = Post Traumatic Stress Disorder; BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory; PSS = Perceived Stress Scale.

** = Correlation is significant at the .01 level (2-tailed); * = Correlation is significant at the .05 level (2-tailed)

Data for forty-nine participants were included in these analyses.

Correlational analyses were conducted to examine the relationship between disorders/self-rated difficulties (BDI, BAI, PSS, Memory Rating, Attention Rating) and performance measures on the Computerized Trail Making Test (Number Speed, Number Accuracy, Alternating Speed, Alternating Accuracy, and Alternating-Number Speed Difference Score). See Table 7 for correlational analyses results for the Trail Making Test.

The three variables that were significantly correlated with Number Speed, (BAI Score, PSS Score, and Attention Rating) were entered as predictor variables in a multiple linear regression. The regression model was significant (R^2_{adj} = .118, F(3,45) = 3.14, p = .034). Neither of the variables, PSS, (β = -.191, t = -1.28, p = .207), BAI, (β = -.124, t <1), nor Attention Rating, (β = -.240, t = -1.60, p = .108) significantly predicted Number Speed.

The two variables that were significantly correlated with Number-Alternating Speed Difference (BAI, and BDI), were entered as predictor variables in a multiple linear regression analysis. The regression model was significant, (R^2_{adj} = .101, F(2,46) = 3.69, p = .032). Neither of the variables, BAI, (β = -.188, t = -1.06, p = .294), nor BDI, (β = -.233, t -.126, p = .215) significantly predicted Number-Alternating Speed Difference.

Given the significant positive correlation between the two accuracy measures and mTBI, a post-hoc analysis was completed using a 2 (Group: Control vs. mTBI) X 2 (Number Accuracy vs. Alternating Accuracy) repeated measures ANOVA. There were no significant main effects or interactions (F<1).

Table 6

Mean Scores and Standard Deviations for Digit Span, Trail Making, and Logical Memory tasks for Veteran Control and mTBI Groups.

	Control Veterans		Veterans with mTBI	
Task	n	Mean (SD)	n	Mean (SD)
Digit Span	36			
Digits Forward		7.31 (1.22)	22	7.36 (.85)
Digits Backward		6.29 (1.53)	22	5.64 (1.22)
Trail Making	28		21	
Number Speed		59.39 (9.73)		61.25 (7.53)
Alternating Speed		86.61 (17.52)		89.35 (16.26)
Number Alternating Speed Difference		27.22 (11.88)		28.1 (13.98)
Number Accuracy		.95 (.03)		.97 (.02)
Alternating Accuracy		.93 (.05)		.96 (.03)
Logical Memory	32		18	
Immediate Raw Score		18.31 (6.05)		18.33 (6.05)
Delayed Raw Score		14.56 (5.83)		15.72 (7.04)
Immediate Total Words		73.47 (19.58)		74.89 (24.34)
Delayed Total Words		73.56 (27.13)		80.44 (35.27)
Immediate Correct Ideas		20.84 (6.92)		21.22 (6.10)
Delayed Correct Ideas		17.03 (7.01)		18.61 (8.02)

Note. All speed scores are reported in seconds. Trail Making accuracy reported as an average proportion correct.

Table 7

Pearson Product Moment Correlation Coefficients and p values for Self-Assessments and Trail Making Scores (n = 49).

	mTBI	PTSD	BDI	BAI	PSS	Memory Rating	Attention Rating	A Speed	A Accuracy	B Speed	B Accuracy
A Speed	.105 (.471)	.066 (.652)	.233 (.106)	**.285*** **(.047)**	**.303*** **(.035)**	-.115 (.432)	**.333*** **(.019)**	_	_	_	_
A Accuracy	**.390**** **(.006)**	.199 (.170)	.078 (.594)	.066 (.652)	-.176 (.225)	-142 (.330)	.030 (.835)	.120 (.412)	_	_	_
B Speed	.081 (.579)	-.141 (.336)	-.136 (.352)	-.099 (.498)	-.019 (.897)	-.084 (.568)	.192 (.197)	.677** (<.001)	.226 (.119)	_	_
B Accuracy	**.289*** **(.044)**	.131 (.368)	.175 (.230)	.259 (.072)	.004 (.980)	-.007 (.964)	.146 (.318)	-.071 (.630)	.590** (<.001)	-.296* (.039)	_
B – A Speed	.035 (.813)	-.233 (.107)	**-.343*** **(.016)**	**-.330*** **(.021)**	-.235 (.103)	-.031 (.831)	.024 (.871)	.206 (.155)	.217 (.135)	.860** (<.001)	-.344* (.015)

Note. mTBI = Mild Traumatic Brain Injury; PTSD = Post Traumatic Stress Disorder; BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory; PSS = Perceived Stress Scale, A = Number only condition, B = Alternating Condition, B – A = Condition B speed minus Condition A speed.

** = Correlation is significant at the .01 level (2-tailed); * = Correlation is significant at the .05 level (2-tailed)

Logical Memory 1 and 2. Due to technical difficulty, eight audio files were lost. A total of fifty audio files were transcribed and analyzed for Logical Memory measures.

Correlational analyses were conducted to examine the relationship between disorders/self-rated difficulties (mTBI, PTSD, BDI, BAI, PSS, Memory Rating, Attention Rating) and Performance on the Logical Memory 1 and Logical Memory 2 measures (Raw Scores, Correct Ideas, and Total Words Produced). See Table 8 for Logical Memory correlational analyses results.

The variables significantly correlated with Correct Ideas in the Immediate Condition, (PSS, BAI, and Attention Rating) were entered as predictor variables in a multiple regression analysis. The model was not significant, ($R^2_{adj} = .09$, $F(3,46) = 2.63$, $p = .062$).

Complex Span Tasks. Operation Span data was missing for one participant and Symmetry Span data were missing for three participants due to computer error resulting in only partially completed trials. Correlational analyses were conducted to examine the relationship between disorders/self-rated difficulties (mTBI, PTSD, BDI, BAI, PSS, Memory Rating, Attention Rating) and performance on the Complex Working Memory Span Tasks (Operation Span Score and Symmetry Span Score). See Table 9 for correlational analysis results.

The variables significantly correlated with Operation Span Score (mTBI, BDI Score, and Memory Rating) were entered as predictor variables in a multiple linear regression. The regression model was significant ($R^2_{adj} = .180$, F (3,53) = 5.08, $p = .004$).

Table 8

Pearson Product Moment Correlation Coefficients and p values for Self-Assessments and Logical Memory Scores (n = 50).

	mTBI	PTSD	BDI	BAI	PSS	Memory Rating	Attention Rating	LM1 Raw Score	LM2 Raw Score	LM 1 Total Words	LM2 Total Words	LM1 Correct Ideas
LM1 Raw Score	.002 (.991)	-.140 (.333)	-.214 (.136)	-.269 (.059)	-.231 (.107)	.228 (.112)	-.271 (.057)	_	_	_	_	_
LM2 Raw Score	.090 (.534)	-.175 (.224)	-.215 (.133)	-.115 (.428)	-.276 (.053)	.274 (.054)	-.245 (.086)	.874** (<.001)	_	_	_	_
LM 1 Total Words	.033 (.823)	-.067 (.645)	-.186 (196)	-.133 (.359)	-.105 (.467)	**.381** (.006)**	-.229 (.110)	.679** (<.001)	.648** (<.001)	_	_	_
LM2 Total Words	.111 (.444)	-.106 (.463)	-215 (.133)	-.101 (.487)	-.105 (.470)	**.408** (.003)**	-.214 (.136)	.644** (<.001)	.719** (<.001)	.878** (<.001)	_	_
LM1 Correct Ideas	.028 (.847)	-.117 (.417)	-.232 (.104)	**-284* (.045)**	**- .295* (.038)**	.257 (.072)	**-.281* (.048)**	.961** (<.001)	.870** (<.001)	.683** (<.001)	.678** (<.001)	_
LM2 Correct Ideas	.104 (.471)	-.143 (.322)	-.177 (.218)	-.085 (.557)	-241 (.092)	.276 (.052)	-.220 (.124)	.859** (<.001)	.969** (<.001)	.676** (<.001)	.780** (<.001)	.895** (<.001)

Note. mTBI = Mild Traumatic Brain Injury; PTSD = Post Traumatic Stress Disorder; BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory; PSS = Perceived Stress Scale, LM1 = Logical Memory Immediate Recall, LM2 = Logical Memory Delayed Recall. ** = Correlation is significant at the .01 level (2-tailed); * = Correlation is significant at the .05 level (2-tailed)

Table 9

Pearson Product Moment Correlation Coefficients and p values for Service-Related Conditions and Self-Assessments and Complex Span Scores.

	mTBI	PTSD	BDI	BAI	PSS	Memory Rating	Attention Rating	Symmetry Span
Symmetry Span (n = 55)	-.115 (.405)	-.006 (.966)	-.252 (.064)	-.172 (.210)	-.084 (.544)	.250 (.066)	-.069 (.616)	_
Operation Span (n = 55)	**-.363**** **(.005)**	-.185 (.169)	**-.347**** **(.008)**	-.220 (.100)	.019 (.887)	**.337*** **(.010)**	-.130 (.335)	.383** (.004)

Note. mTBI = Mild Traumatic Brain Injury; PTSD = Post Traumatic Stress Disorder; BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory; PSS = Perceived Stress Scale.
** = Correlation is significant at the .01 level (2-tailed); * = Correlation is significant at the .05 level (2-tailed)

The analysis showed that mTBI significantly predicted Operation Span Score, (β = -.274, t = -2.17, p = .035). Having a history of mTBI predicted lower Operation Span Scores. The other variables, BDI Score, (β = -.193, t = -1.36, p = .181), and Memory Rating (β = .169, t = 1.19, p = .240) did not significantly predict Operation Span Scores. Table 10 summarizes means and standard deviations of scores for veterans with mTBI and healthy controls for all experimental tasks.

Iowa Gambling Task. Electronic data files for two participants were not saved due to a software error. Data for fifty-six participants are included in the IGT analyses.

Correlational analyses were conducted to examine the relationship between disorders/self-rated difficulties (mTBI, PTSD, BDI, BAI, PSS, Memory Rating, Attention Rating) Advantageous Deck Selection Score (combined score for trials 21-100) and Sensitivity to Loss Frequency Score (combined score for trials 21-100) on the IGT. Only mTBI history and Advantageous Deck Selections were correlated. See Table 11 for IGT correlational analyses results.

Because the task requires learning about deck characteristics across trials, a post-hoc analysis was conducted to examine whether veterans with mTBI made fewer advantageous deck decisions than healthy controls in later trials. Based on conventional scoring methods for the IGT, (Bechara, 2007; Bagneux et al., 2013; Cotrena et al., 2014; Brenner et al., 2015), the trials were divided into four blocks of 20 responses. The first 20 blocks were considered a training phase and were not included in the analysis. The data were analyzed with a 2 (Group: Control vs. mTBI) X 4 (Block Advantageous Deck Selection Score for blocks 2, 3, 4, 5) mixed-factor Analysis of Variance (ANOVA).

Table 10

Mean Scores and Standard Deviations for Complex Span, Iowa Gambling, and Serial Addition Tasks for Veteran Control and mTBI Groups.

	Control Veterans		Veterans with mTBI	
Task	n	Mean (SD)	n	Mean (SD)
Complex Span				
Symmetry Span	34	13.88 (6.71)	21	12.48 (4.70)
Operation Span	35	22.06 (6.15)	22	16.82 (7.42)
Iowa Gambling	36		22	
Advantageous Deck Selection		23.44 (24.16)		9.64 (26.05)
Sensitivity to Loss Frequency		7.83 (31.32)		13.00 (26.16)
Serial Addition	36		22	
Total Proportion Correct		.81 (.14)		.78 (.12)
Total Speed Errors		4.56 (8.75)		3.41 (3.89)

Note. Standard Deviations are in parentheses

Table 11

Pearson Product Moment Correlation Coefficients and p values for Service-Related Conditions and Self-Assessments and Iowa Gambling Task Scores.

	mTBI	PTSD	BAI	BDI	PSS	Memory Rate	Attention Rate	Advantageous Block
Advantageous Block	**-.264*** **(.045)**	-.210 (.114)	-.003 (.984)	-.206 (.120)	-.179 (.179)	.087 (.517)	-.207 (.120)	–
Sensitivity to Loss	.089 (.520)	.167 (.211)	.226 (.088)	.184 (.166)	-.126 (.348)	-.040 (.764)	-.039 (.774)	-.117 (.382)

Note. mTBI = Mild Traumatic Brain Injury; PTSD = Post Traumatic Stress Disorder; BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory; PSS = Perceived Stress Scale.
** = Correlation is significant at the .01 level (2-tailed); * = Correlation is significant at the .05 level (2-tailed)

There was a significant main effect of Block ($F(3, 165)=7.34$ $p<.001$, partial $\eta 2=.118$), no significant effect of Group ($F(1,55)=2.29$, $p=.136$, partial $\eta 2=.04$), and a marginally significant Block X Group interaction ($F(3,165)=3.91$, $p=.053$ partial $\eta 2=.066$).

The nature of the interaction was examined by conducting separate analyses for the Control and mTBI groups. For the mTBI group, there was no effect of Block (F<1), indicating that the mTBI group did not respond differently as the task progressed. For the healthy control group, there was a significant effect of Block ($F(3,105)=12.33$, $p<.001$, partial $\eta 2=.261$). Follow up pairwise comparisons were conducted using a Bonferroni correction for an adjusted alpha of .008. Pairwise comparisons revealed increased advantageous deck selections from the 2nd block to the 3rd, 4th, and 5th blocks ($t(35)=-3.43$, $p=.002$, $t(35)=-4.85$, $p<.001$, and $t(35)=-4.36$, $p<.001$ respectively). Veterans with mTBI performed differently from the control veterans in that they did not increase the number of advantageous deck selections in later trials. Healthy control veterans increased advantageous deck selections as the task progressed and then maintained that response pattern (see Figure 5).

Independent t-tests were also conducted to examine group differences for each of the four blocks using a Bonferroni correction for an adjusted alpha of .0125. There were no significant group differences in Advantageous Deck Selection for Block Two, ($t<1$), Block Three, ($t(55)=1.85$, $p=.07$), Block Four, ($t(55)=1.50$, $p=.139$), or Block Five, ($t(55)=1.73$, $p=.089$).

Computerized Serial Addition Task. Correlational analyses were conducted to examine the relationship between disorders/self-rated difficulties (mTBI, PTSD, BDI, BAI, PSS, Memory Rating, Attention Rating) and Performance on the Serial Addition Task (Total Proportion Correct and Total Speed Errors). See Table 12 for correlational analyses results.

The two measures that were significantly correlated with Total Proportion Correct (BDI Score and Memory Rating) were entered as predictor variables in a multiple linear regression analysis. The regression model was significant (R^2_{adj} = .179, F (2,55) = 7.23, p = .002). The analysis revealed that BDI Score significantly predicted Total Proportion Correct, (β = -.330, t = -2.36, p = .022). More severe depression levels predicted lower Total Proportion Correct. Memory Rating did not significantly predict Total Proportion Correct (β = -.189, t = 1.35, p = .182).

Because the current task was programmed to include a greater number of trials than is typical of the clinical version of the task, it is of interest whether performance changed in later trials for veterans with depression. To examine this performance pattern, veterans were divided into two groups based on BDI score for further analysis. Veterans with scores in the moderate to severe depression range (scores $\geq$20) were included in the Depression group, veterans with scores below twenty were included in the Control group. A post hoc analysis was conducted using a 2 (Group: Control vs. Depression) X 2 Half 1 Accuracy, Half 2 Accuracy) mixed-factor Analysis of Variance (ANOVA). There was a significant main effect of Half $F(1,56)=4.48$ $p<.039$, partial $\eta 2=.074$), a significant main effect of Group ($F(1,56)=6.19$, $p=.016$, partial $\eta 2=.100$), and no significant Half X Group

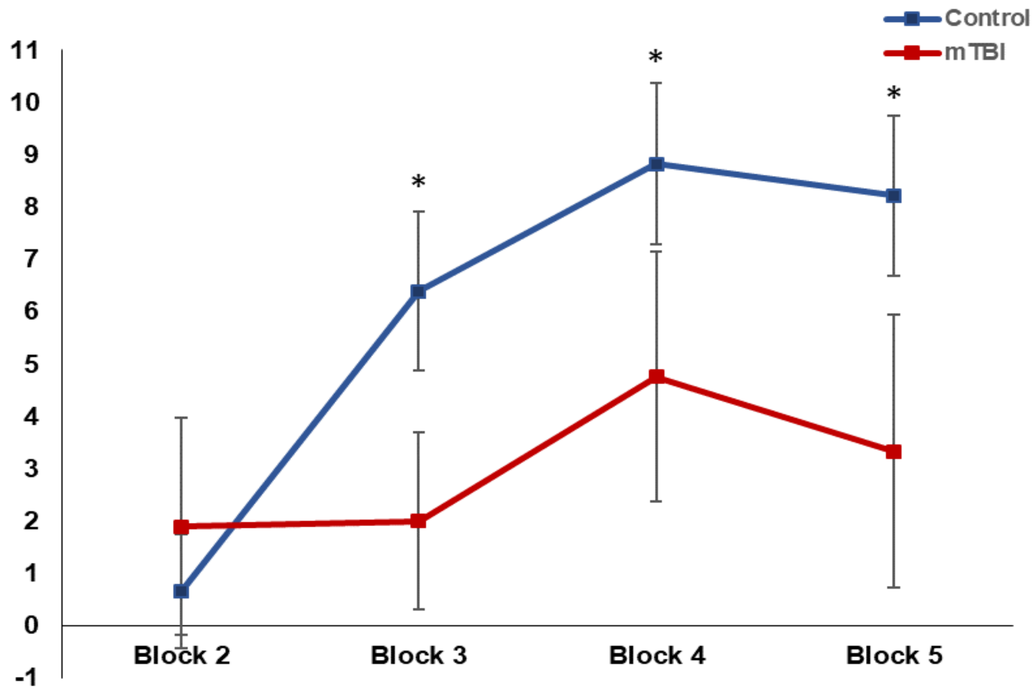

Figure5. Mean Advantageous Deck Scores for the Iowa Gambling Task by Block and Group. Error bars represent standard errors. * Denotes significantly different from Block 2 (p<.008).

Table 12

Pearson Product Moment Correlation Coefficients and p values for Service-Related Conditions and Self-Assessments and Computerized Serial Addition Scores (n = 58).

	mTBI	PTSD	BDI	BAI	PSS	Memory Rating	Attention Rating	Proportion Correct
Proportion Correct	-.128 (.337)	-.007 (.959)	**-.426** (.001)**	-.190 (.154)	-.099 (.006)	**.358** (.066)**	-.109 (.416)	_
Speed Errors	-.077 (.565)	-.081 (.546)	**.281* (.033)**	**.263* (.046)**	.176 (.187)	-.170 (.203)	.118 (.379)	**-.764** (<.001)**

Note. mTBI = Mild Traumatic Brain Injury; PTSD = Post Traumatic Stress Disorder; BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory; PSS = Perceived Stress Scale.
** = Correlation is significant at the .01 level (2-tailed); * = Correlation is significant at the .05 level (2-tailed)

interaction ($F(1,56)=2.83$, $p=.098$ partial $\eta 2=.048$). Independent sample t-tests showed that there was no difference in accuracy between the groups in the first half of trials, ($t(56)=1.66$, $p=.101$), but there was a significant difference in accuracy in the second half of trials, ($t(56)=3.04$, $p=.004$). Veterans with moderate to severe depression scored lower than veterans with mild to no depression in later trials (see Figure 6).

The two variables that were significantly correlated with Total Speed Errors (BAI Score and BDI Score) were entered as predictor variables in a multiple linear regression analysis. The regression model was not significant ($R^2_{adj} = .057$, $F(2,55) = 2.70$, $p = .075$).

Discussion

The purpose of this study was to determine whether service-related conditions and self-assessments predict performance on complex working memory and executive function tasks for military veteran college students. It was predicted that commonly used neuropsychological tasks would not be sensitive to service-related conditions, nor to the self-reported symptoms of memory and attention difficulties in veterans. Findings were largely consistent with this prediction. It was hypothesized that more complex, higher-order cognitive tasks would be sensitive to self-assessment and service-related conditions. This hypothesis was supported regarding mTBI and depression and performance on complex verbal working memory and executive function tasks.

Service-Related Conditions and Inventory Scores. The first specific aim was to determine whether a history of mTBI, PTSD, or self-rated memory and attention

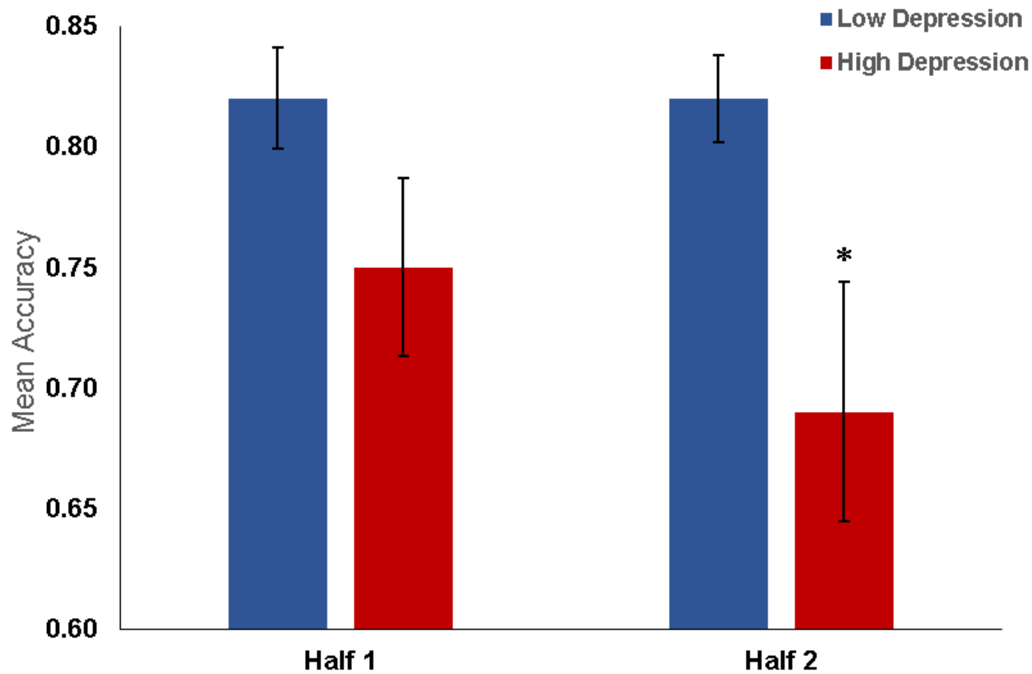

Figure 6. Mean accuracy for the first and second half of the Serial Addition Task by Group. Error bars represent standard errors. *Denotes significantly different from Low Depression Group ($p<.05$).

difficulties predict anxiety, depression, and stress severities. Based on previous research, (Lew et al., 2008), it was expected that mTBI history would predict higher levels of anxiety, depression, and stress. However, that relationship was not observed in these data based on the scales utilized in this study, BDI, BAI, and PSS. Of note, the proportions of veterans reporting clinically significant levels of stress, anxiety, and depression in both the mTBI and healthy control groups were relatively equally distributed. Therefore, it is possible that other service-related factors, such as deployment or combat exposure may be influencing the prevalence and severity of these conditions. Indeed, Hoge et al., (2004) found that combat and deployment to Iraq or Afghanistan predicted increased depression and anxiety. A post-hoc correlational analysis was completed to explore the relationship between deployment history and depression, anxiety, and stress. Deployment history was not correlated to scores for BDI, ($r(58) = .140$, $p = .293$), BAI, ($r(58) = -.057$, $p = .672$), or PSS, ($r(58) = -.097$, $p = ..471$) in this sample.

A diagnosis of PTSD did significantly predict depression severity, as was anticipated. Veterans with PTSD had more severe depression scores on the BDI. Unlike the relatively equal distribution of depression across mTBI and veteran control groups, when veterans were grouped according to PTSD, the distribution of veterans with depression looked different. In this study, significantly more veterans with PTSD scored in the moderate to severe range of depression as measured by the BDI, ($\chi^2 = 11.12$, $p = .001$). This distribution is consistent with the documented overlap of symptoms between PTSD and depression and high rates of comorbidities. In addition, the findings of this study are consistent with previous studies showing high rates of comorbid PTSD and depression (Ginzburg et al., 2010; Pineau et al., 2014**)**.

Service-Related Conditions and Self-Ratings. Depression was also a significant predictor of self-report of memory difficulty. Veterans who scored more severe range on the BDI rated their general memory abilities as worse. This relationship was expected, given that memory, deficits have been documented in patients diagnosed with depression (Burt, Zembar, and Niederehe, 1995; Ross, Putnam, Gass, Bailey, & Adams, 2003). None of the other service-related conditions significantly predicted self-rating of memory skills. Researchers report high depression rates among OIF/OEF veterans, some as high as 47% (Taylor et al., 2012). With such high rates, it is important to investigate the relative contribution of service-related conditions to depression. One factor warranting further exploration is the relationship between substance abuse and PTSD, depression, anxiety, and stress in military veterans.

Given the comorbidity and overlap in symptoms between PTSD and anxiety (Marshall et al., 2010; McMillan & Asmundson, 2014), it was surprising that PTSD did not predict elevated anxiety severity. It is a reasonable possibility that with the symptom overlap between depression, anxiety, and PTSD, depressive symptoms are more pronounced than anxiety symptoms resulting in a greater endorsement of depression symptoms than anxiety symptoms in veterans with PTSD. Some studies have suggested that gender may play a role in comorbidity of anxiety, depression, and PTSD (Spinhoven et al., 2014). In this study, there were too few female participants to examine the role of gender formally. However, proportions of females reporting moderate to severe anxiety, depression, and a diagnosis of PTSD were similar to the proportion of males reporting these conditions. See Table 13 for numbers and percentages of males and females reporting PTSD, depression, and anxiety.

Table 13

Number of Males and Females reporting a diagnosis of PTSD and scoring in the moderate to severe range on the Beck Depression Inventory and Beck Anxiety Inventory (percentages in parentheses).

	Male (n = 49)	Female (n = 9)
Condition		
PTSD	13 (26.5)	2 (22.2)
Depression	10 (20.4)	3 (33.3)
Anxiety	12 (24.5)	3 (33.3)

Clinical Attention and Memory Assessments. The second aim was to evaluate whether service-related conditions and self-assessments predicted performance on neuropsychological tasks commonly used to measure attention and working memory. These clinical assessment tasks were included because although they are frequently used in studies examining cognitive performance associated with mTBI in military veterans, the tasks have not been shown to be sensitive to subtle deficits that may be associated with mTBI or other service-related conditions. Therefore, it was anticipated that mTBI, PTSD, depression, anxiety, stress, self-assessed memory difficulty, and self-assessed attention difficulty would not predict performance on Trail Making or Digit Span tasks, commonly used neuropsychological tasks. Findings supported this prediction for the Computerized Trail Making tasks. None of the service-related conditions or self-rated memory or attention difficulties significantly predicted performance on either condition (number only or alternating numbers and letters) using any of the performance measures (speed, accuracy, or speed difference) for the Computerized Trail Making task.

This study adds to the evidence reported by previous researchers, (e.g., Gordon et al., 2011) that the Trail Making task is not sensitive to long-term symptom reports associated with mTBI or other service-related conditions or difficulties in military veterans. Despite being a widely used measure of attentional control, set-shifting, and working memory, mTBI, anxiety, depression, and PTSD did not predict performance on accuracy or speed measures in either condition or on the derived measure (Alternating Speed – Number Speed) on the task for military veterans. The Trail Making task has been shown to be sensitive in acute phases of mTBI recovery (Lange et al., 2005) and participants with moderate to severe TBI (Armstrong et al., 2008), but may not be reliably sensitive to more mild brain injuries.

The findings were also largely as expected for the simple span tasks. Although none of the service-related conditions or difficulties had a significant relationship with Digits Backward performance, the same was not true for performance in the Digits Forward condition. High anxiety significantly predicted lower digit forward span scores. The Digits Backwards task is often viewed as the more complex task, requiring manipulation beyond simple recall as in the Digits Forward condition (Lezak et al., 2005). There are a couple of reasons why anxiety may have predicted poorer performance on Digits Forward, but not Digits Backward. First, this finding is consistent with previous research showing that anxiety was related to lower span scores in the Digits Forward condition and that the relationship was significantly reduced with practice (Mueller & Overcast, 1976). In the current study Digits, Forward was consistently administered immediately preceding Digits Backward. There may be an element of decreased anxiety after the initial task, allowing learning and strategy development and subsequently resulting in less impact of anxiety on performance in the second condition of the task, Digits Backward. Future research should include counterbalancing the conditions to examine the impact of order effects.

Most importantly, the findings related to Digits Forward and Digits Backward in this study provide further evidence that these measures are not sensitive to neuropsychological deficits associated with mTBI and PTSD. Researchers continue to include these tasks and draw conclusions about working memory in veterans with mTBI based in part on digit span performance (Pineau et al., 2014; Verfaellie et al., 2014). However, these tasks rely on simple, immediate recall, not working memory, and do not reflect real-world demands. Even though the digits backward task is considered more complex, researchers have provided evidence that digits forward and backward measure the same cognitive processes (St. Claire-Thompson & Allen, 2013). Although drawing conclusions about working memory using simple span task performance is not supported by the current data, there is potential value to including simple span tasks as measures of effort in experimental protocols examining higher-order cognitive processing.

Researchers have included both digit span forward and backward tasks as a measure of effort (Heinly, Greve, Bianchini, Love, & Brennan, 2005; Zenisek, Millis, Banks, & Miller, 2016) using a Reliable Digit Span Score (RDS), (Heinely et al., 2005; Loring, Goldstein, Chen, Drane, Lah, Zhao, & Larrabee, 2016). The RDS calculation is made by combining the highest span where both trials were accurately recalled in both the forward and backward condition. An RDS of $\leq$7 is considered evidence of lack of effort (Schroeder, Twumasi-Ankrah, Baade, & Marshall, 2012). In the current study's sample, no participant earned an RDS below ten. Even veterans reporting memory and attention difficulties earned RDS Scores within the acceptable range, providing evidence of sufficient effort and evidence against malingering. Therefore, the inclusion of these tasks in future studies may be relevant as a measure of effort, but not to identify working memory deficits.

Immediate and delayed recall of narrative information is another commonly used memory measure. Although it was not anticipated that service-related conditions would predict poorer performance in the immediate recall condition, it was expected to predict poorer performance in the delayed condition. Results did not support this hypothesis for any of the scoring procedures used. The scoring procedures were selected based on results from a previous study (Gallagher & Azuma, 2016) that showed veterans with mTBI performed similar to healthy controls across all three scoring approaches in the immediate condition but significantly worse in the delayed condition (lower raw score, fewer correct ideas, and fewer total words).

A possible explanation for lack of relationship between mTBI and Logical Memory measures in this sample lies in the procedures developed specifically for this study. In an attempt to standardize the story presentation for all participants, the task was modified so that story retells were elicited using video-recorded stories presented via computer versus the previously used live procedure prescribed by the test manual. Relative to the live presentation, scores for all measures for all participants decreased across both immediate and delayed conditions. For this study, scores from previous data sets were not formally compared to current scores. However, it would be beneficial to examine performance differences across elicitation procedures and delay conditions formally.

Complex Working Memory and Executive Function. The third aim was to determine whether history of mTBI, PTSD, depression, anxiety, and stress, and self-rated memory and attention difficulties predict poorer performance on complex working memory and higher-order cognitive tasks.

Complex Working Memory. First, in contrast to the simple span tasks, service-related conditions were anticipated to predict performance on complex working memory tasks. Again, the findings of this study partially support this hypothesis. There were no significant relationships between any of the service-related conditions and Symmetry Span Total Score. However, for the Operation Span Task, history of mTBI significantly predicted lower Operation Span Total Score.

Ample research has demonstrated the link between complex span tasks and higher-order cognitive processes (Chein et al., 2010; Kane et al., 2004; Unsworth et al., 2009). Although both Symmetry Span and Operation Span tasks are complex working memory tasks that include storage and processing components, (Turner & Engle, 1989), they are different regarding the type of working memory span each purport to measure. Symmetry Span is a non-verbal complex working memory span task, where the Operation Span task is a verbal complex working memory span task. Interestingly, Symmetry Span is thought to be a more complex task (Christopher Draheim, Harrison, Embretson, & Engle, 2017). However, because it was designed to limit reliance on verbal aspects of working memory, performance in veterans with histories of mTBI may not be as affected.

There is evidence that language areas contribute to a wide range of cognitive tasks (Fedorenko et al., 2013; Hagoort, 2014). In addition, researchers have shown that higher-order cognitive-linguistic functions that place demands on frontal lobe networks are sensitive to diffuse neurological deficits associated with TBI, (Hinchliffe & Murdoch, & Chenery, 1998) and even mTBI (Barwood & Murdoch, 2013; Whelan & Murdoch, 2006). Results of this study provide evidence that complex verbal working memory may be vulnerable to long-term consequences of mTBI. Verbal working memory deficits can adversely impact processing of complex syntax (Caplan & Waters, 1999) and discourse (Youse & Coelho, 2005; Salis, 2011) and, therefore, may impact everyday language use.

Performance on complex span tasks has also been shown to predict performance on a wide variety of cognitive skills (Daneman & Carpenter, 1980; Engle, Tuholski, Laughlin, & Conway, 1999), including fluid intelligence. There are significant academic implications for veterans with mTBI who are entering college after service. Verbal working memory difficulties may adversely impact a variety of academic tasks reliant on complex language processing, such as reading comprehension (Daneman & Carpenter, 1980; Kane et al., 2004), and note-taking skills (Bui & Myerson, 2014; Peverly et al., 2013).

Executive Function and Decision Making For the task examining complex decision making and probabilistic learning, the IGT, the only significant correlation for any scoring procedure and service-related condition/self-assessment was between mTBI and Total Advantageous Deck Selection Score. Given that this task requires participants to make decisions based on reward and punishment feedback, a post hoc analysis was warranted to explore the relationship between mTBI and the learning component of the IGT. By separating the responses into blocks of twenty, a common scoring method utilized in research, (Bechara, 2007; Bagneux et al., 2013; Cotrena et al., 2014; Brenner et al., 2015), an examination of group learning differences was possible. The results showed different performance patterns for veterans with mTBI compared to healthy control veterans. Healthy control veterans demonstrated an increased selection of the advantageous decks in later trials. However, veterans with mTBI did not increase advantageous deck selections in later trials.

Decision making is an aspect of executive function that is particularly relevant for veterans entering college given the implications for daily decision-making as well as learning. The IGT mirrors real-world decision making by assessing the ability to evaluate outcomes and integrate the information for future selections. For veterans with a history of mTBI, the lack of increased advantageous deck selection in later trials may be indicative of a propensity toward high-risk behavior, a factor often associated with TBI. Veterans with no mTBI history applied feedback from previous deck selections to inform future decisions. They increasingly made more advantageous deck selections over time in contrast to veterans with mTBI who did not integrate the adverse feedback to make more advantageous selections. The results provide evidence that veterans with histories of mTBI have greater difficulty monitoring response outcomes and applying the learning to subsequent responses to obtain advantageous outcomes. This response pattern, whether driven by an increased tendency toward risky behavior, or lack of outcome monitoring, has clear implications for academic, vocational, and even social success.

Although it was anticipated that mTBI history and PTSD would predict performance on the Computerized Paced Visual Serial Addition Task, the results of this study do not support that hypothesis. The original Paced Auditory Serial Addition Task has been used as a measure of concussion recovery (Gronwall, 1977), and shown by some to be sensitive to long-term symptom complaint associated with mTBI, (Cicerone and Azulay, 2002). However, in their study, Fos et al.,(2000) did not find that the visual serial addition task was sensitive to mTBI in young adults. Results from this study are consistent with the findings that mTBI does not predict poorer performance on this serial updating task. Instead, depression severity as measured by the BDI predicted lower proportion correct on the serial addition task. These findings are not surprising given the prior research highlighting the relationship between depression and executive dysfunction (Fossaati et al., 2002; Merriam et al., 1999). There is also a foundation for a relationship between versions of this serial updating task and depression based on prior utilization in studies related to depression, (Feldner, Leen-Feldner, Zvolensky, & Lejuez., 2006) and induction of negative affect (Holdwick, & Wingenfeld, 1997; Strauss, Sherman, and Spreen, 2006).

Interestingly, the post hoc analysis showed that it was only in the later trials that veterans with moderate to severe depression performed significantly differently than veterans with mild to no depression. These results have implications regarding academic performance for the high numbers of military veterans diagnosed with depression. Veterans with moderate to severe depression may have increased difficulty on high pressure, stress-inducing tests or tasks that extend over longer periods of time, such as the GRE or MCAT, or even final exams. Future research is needed to determine if depression adversely impacts academic test performance and to examine whether variables, such as task breaks, significantly reduce the impact of depression on performance in high-pressure, extended time tasks.

Self-Report of Symptoms. It was hypothesized that self-reported memory and attention difficulties would significantly predict poorer performance on higher-order cognitive processing tasks. Memory self-ratings and attention self-ratings were factors included in correlational analyses for all tasks in this study protocol. Results did not show that self-assessment of memory and attention were predictive of performance. However, in examining the frequencies of conditions and reported difficulties (Table 2), a higher proportion of veterans with mTBI have PTSD and a higher proportion report on-going memory difficulties compared to veterans with no mTBI history. A marginally higher proportion reported on-going attention difficulties. As was discussed earlier, a greater number of veterans with PTSD scored in the moderate to severe depression range. Given the overlap of cognitive-related symptoms in mTBI, PTSD, depression, and anxiety, it is difficult to determine the relative contribution of each to the overall cognitive profile (Karr et al., 2014; Lange et al., 2015). It is a web of concomitant service-related conditions with significantly overlapping, possibly inextricably linked, cognitive symptoms.

Limitations and Future Directions. Disentangling the etiologies of each reported cognitive symptom is well beyond the scope and intention of this study. Regardless of the etiology, deficits were substantiated by performance patterns on some complex working memory and attention tasks, but not some of the typically administered neuropsychological tasks. This study provides evidence that some complex working memory and executive function tasks are sensitive to subtle, long-term deficits associated with mTBI in military veterans. This study also provides evidence that mental health conditions frequently diagnosed in military veterans, specifically depression and anxiety, may impact aspects of learning, attention, and working memory, and have clear implications for learning and academic success. Depression is well researched in military veterans, but the prevalence and severity of anxiety have not been sufficiently studied in military veterans. Anxiety is often combined with addiction or PTSD, and separate prevalence numbers are not reported. However, as in this study, PTSD and anxiety were not significantly related.

In this study, addiction and substance abuse issues and prevalence were not explored. Participants were not asked about their legal or illegal substance use due to the sensitive nature of those questions. Because researchers have shown a high incidence of substance abuse associated with service-related conditions, (Coker, Stefanovics, & Rosenheck, R. 2015), future research should consider the relationship of substance abuse to cognitive and academic performance in military veterans with histories of mTBI, PTSD, depression, and anxiety. It should further examine the impact on the severity of depression, anxiety, and PTSD, as well as the relationship of substance abuse and report of unremitting mTBI symptoms.

Another consideration for future research is the inclusion of veterans in a community college or at the pre-college stage. The veterans in this sample were all students enrolled at a four-year university. Placement in this setting can be considered evidence of academic success compared to enrollment in a smaller, less competitive environment, such as community college. Veterans who have earned admission to a four-year university setting have likely successfully completed college pre-requisites or may have completed entry-level coursework. Examining cognitive performance patterns in veterans at earlier stages of post-secondary education may provide information about factors predictive of academic success. Exploration of these patterns may also inform intervention approaches.

Finally, the sample in this study included a small number of female veterans. Although the gender distribution is representative of the distribution of women and men in the military, it would be beneficial to include a more robust female sample to examine the prevalence of mTBI, PTSD, depression, and anxiety in female veterans compared to male veterans. Future studies should also examine self-assessment differences along with performance differences on complex cognitive tasks in female versus male veterans.

Conclusions. The results of this study provide evidence of working memory and executive function difficulties associated with frequently occurring service-related conditions. Previous research has offered limited and conflicting findings regarding cognitive performance and the relationship to mTBI in military veterans. However, in this study, verbal working memory and decision-making difficulties were significantly predicted by a history of mTBI in military veterans. In addition, another commonly occurring service-related condition, depression, significantly predicted poorer performance on an executive function task. In contrast, the commonly used clinical neuropsychological tasks were not sensitive mTBI or depression. The differing performance patterns observed between the clinical tasks and the more complex experimental tasks indicate that the subtle, higher-order cognitive deficits associated with mTBI and depression should be evaluated with tests that sufficiently tax verbal working memory and executive function. In other words tasks should be complex and allow for a sufficient number of trials. These findings provide direction for tailoring assessments to include complex cognitive-linguistic tasks that more closely replicate real-world demands and that may be more sensitive to subtle deficits significantly impacting veterans as they enter cognitively demanding environments, such as college or vocational training programs.

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APPENDIX A

ONLINE VETERAN QUESTIONNAIRE

Veteran Survey

Thank you for participating in this study! Be sure to use the participant code that was given to you in the email message.

* Required

1. Please enter your participant code. *

2. To confirm, please re-enter your participant code. *

3. What is your age? *

4. Sex:

   Mark only one oval.

   - Male
   - Female

5. Race

   Check all that apply.

   - American Indian / Alaska Native
   - Asian
   - Black / African American
   - Hawaiian or Other Pacific Islander
   - White

6. Are you Hispanic? Mark only one oval.

   - Yes
   - No

7. Is English your native (first) language? Mark only one oval.

- Yes
- No

8 If English is not your native language, what is your native language?

....

9. Are you an international student?
Mark only one oval.

- Yes
- No

Developmental and Educational History

10. What was the highest level of education you completed before entering the military? Mark only one oval.

- Some high school
- GED
- High School Graduate
- 1 semester of college
- 2 semesters of college
- 3 semesters of college
- 4 or more semesters of college

11. In school, if you had an Individualized Education Plan (IEP) (i.e. get speech therapy, or physical therapy), what was the IEP for? If you did not have an IEP, please state "NO."

....

....

....

....

....

12. **In high school, what was your approximate** GPA?

13. Was your high school GPA weighted or unweighted?
Mark only one oval.

- weighted
- unweighted

14. What year did you graduate from high school or earn your GED?

15 Please specify how many college credits you earned while you were in high school or in the military. If none, type 0.

16. How many months after high school did you FIRST begin taking college classes?

17. Where did you first being taking college classes?
Mark only one oval.

- Community College - online classes
- Community College - in person classes
- 4 year university - online classes
- 4 year university - in person classes

18. How many months post-high school have you been taking college classes?

19. Have you been continuously enrolled in college classes? Mark only one oval.

- Yes
- No

20. What is your current college GPA (for all college coursework including community college)?

21. Not including the current semester, how many total credits have you earned at the COMMUNITY COLLEGE level?

....

22. Not including the current semester, how many total credits have you earned at the 4 YEAR UNIVERSITY level?

....

23. Is this your first semester at ASU? Mark only one oval.

- Yes
- No

24 How many college credits are you registered for in the upcoming semester?

....

25. Please provide the Course Prefix and Number of all of the classes you are registered for the upcoming semester (e.g., PGS 101). If the class is online, please type ONLINE.

....

....

....

....

....

26. **What is your college major?**

....

27. What degree are your currently pursuing? Mark only one oval.

- BS
- BA
- Master's
- .... Other:

28. How long in total do you think it will take you to finish the degree you are currently working on?

29. Do you think you will run out of veteran's educational benefits before completing your degree?

Mark only one oval.

- Yes
- No

30. If you answered "yes" to the previous question, please tell us why.

31 Will this be your first college degree?

Mark only one oval.

- Yes
- No, I already have a AA.
- No, I already have a BA/BS.
- Other: ____________

32. For the following items, rate your expectations for this semester: Mark only one oval per row.

	Excellent	Good	Average	Fair	Poor	N/A
Your performance on tests						
Your performance on homework						
Your ability to keep materials organized for classes						
Your ability to consistently turn in assignments on time						
Your ability to attend classes (for in-person classes)						
For online courses, your ability to manage the online content.						

33. For the following items, rate your expectations for this semester:

Mark only one oval per row.

	Excellent	Good	Average	Fair	Poor	N/A
Your ability to keep up with assignments and readings	⬭	⬭	⬭	⬭	⬭	⬭
Your ability to focus during class lectures.	⬭	⬭	⬭	⬭	⬭	⬭
Your ability to focus during tests.	⬭	⬭	⬭	⬭	⬭	⬭
Your ability to remember information for tests.	⬭	⬭	⬭	⬭	⬭	⬭
Your ability to organize ideas for written assignments.	⬭	⬭	⬭	⬭	⬭	⬭

34 Please select one of the following statements: Mark only one oval.

- I think I perform better in online classes than in-person classes.
- I think I perform worse in online classes than in-person classes.
- I think I perform equally well in online classes and in-person classes.
- I only take online classes.
- I only take in-person classes.

35. Select the statement that best describes your performance in your college classes: Mark only one oval.

- 5 = I earn the highest grades in my classes.
- 4 = I earn higher grades than most students in my classes.
- 3 = I earn the same grades as most students in my classes.
- 2 = I earn lower grades than most students in my classes.
- 1 = I earn the lowest grades in my classes.

36. Select the statement that best describes your OVERALL memory (your memory in your everyday life):

Mark only one oval.

- 5 = My memory is much better than other people my age.
- 4 = My memory is somewhat better than other people my age.
- 3 = My memory is about the same as other people my age.
- 2 = My memory is somewhat worse than other people my age.
- 1 = My memory is much worse than other people my age.

37. Select the statement that best describes your memory for information taught IN CLASSES: Mark only one oval.

- 5 = My memory for class information is much better than other students.
- 4 = My memory for class information is somewhat better than other students.
- 3 = My memory for class information is about the same as other students.
- 2 = My memory for class information is somewhat worse than other students.
- 1 = My memory for class information is much worse than other students.

38. Please rate your OVERALL level of anxiety (anxiety experienced in your everyday life) Mark only one oval.

- 1 = No anxiety
- 2 = Some anxiety
- 3 = Moderate anxiety
- 4 = Fairly Severe Anxiety
- 5 = Extremely Severe Anxiety

39 Please rate your typical level of TEST anxiety (anxiety experienced while taking an exam) Mark only one oval.

- 1 = No anxiety
- 2 = Some anxiety
- 3 = Moderate anxiety
- 4 = Fairly Severe Anxiety
- 5 = Extremely Severe Anxiety

40. Do you think your test anxiety level is the same, more, or less than other students? Mark only one oval.

- More test anxiety
- Same test anxiety
- Less test anxiety

41. Select the statement that best describes your ability to attend (your attention skills) in environments with normal distractions (ex: other people talking in a room; TV playing, etc.) Mark only one oval.

- ⬭ 1 = I usually experience no problems with attending with such distractions.
- ⬭ 2 = I usually experience minor difficulty attending with such distractions.
- ⬭ 3 = I usually experience moderate difficulty attending with such distractions.
- ⬭ 4 = I usually experience severe difficulty attending with such distractions.

42. Please select all of the following situations in which you experience MORE THAN TYPICAL DIFFICULTY with attention: Check all that apply.

- ☐ I have difficulty tuning out voices around me
- ☐ I have difficulty paying attention to more than one thing at a time
- ☐ I have difficulty tuning out environmental noises (e.g. air conditioning)
- ☐ I have difficulty paying attention to visually distracting things (e.g. lecture slides with a lot of words on them)
- ☐ I have difficulty tuning out small noises (e.g. someone shifting in a seat near me)

43. Which do you find more distracting visual or auditory distractions? Mark only one oval.

- ⬭ Visual distractions
- ⬭ Auditory distractions
- ⬭ They are equally distracting

44 What modifications or accommodations (e.g. longer time for tests, note taker) for tests and assignments do you currently receive from the Disability Resource Center (DRC)? Check all that apply.

- ☐ I do NOT receive accommodations from the DRC
- ☐ Longer test times
- ☐ Note-Taker
- ☐ Other: ____________________

45. Please rate the following academic subjects on how difficult you find them. Mark only one oval per row.

	Very Easy	Fairly Easy	Neutral	Fairly Difficult	Very Difficult
Math					
Literature					
Science					
Writing (essays)					
History					
Foreign Languages					

46. If you will be working while you are attending college, please list your job title and the number of hours you will work each week. If you will not be working, please type N/A.

47. If you receive VA or other veteran benefits for academic support (for example, Post 9/11 GI Bill), please describe the benefits. If you are not receiving any benefits, type N/A.

48. Will you be the first in your family to get a college degree? Mark only one oval.

- Yes
- No

49 If you are NOT the first in your family to get a college degree, please list the degrees earned by your mother, father, and brothers/sisters.

50. **What was your father's occupation?**

51. What was your mother's occupation?

Military Background

52. Are you still currently serving in the military?
Mark only one oval.

- ( ) Yes
- ( ) No

53. If you are still CURRENTLY serving in the military, please list your current status and branch (ex: Navy Reserves).

54. How old were you when you joined the military?

55. What branch of service did you serve in?

56. **What is/was your military occupation (MOS)?**

57 Were you Airborne or Special Forces? If so, please describe:

58. How many years did you serve?

59. If you were deployed overseas, please specify WHERE and FOR HOW LONG you were deployed. If you were not, type N/A.

60. **If you served in IRAQ, please state how long** you served there. If you did not, type N/A.

61. If you served in Afghanistan, please state how long you served there. If you did not, type N/A.

62. If you receive disability compensation from Veterans Administration, for what conditions are you compensated? If none, type N/A.

63. **If you receive disability compensation from** VA, what is your disability rating?

Medical History

64 If you have vision problems, please describe them. If you do not, type "none."

65. If you have a hearing loss, please describe it. If you do not, type "none."

66. **Have you ever been diagnosed with PTSD?**

Mark only one oval.

- Yes
- No

67. If you have been diagnosed with PTSD, how old were you when you received the diagnosis and who made the diagnosis?

68. **Have sustained any blast injuries?**

Mark only one oval.

- Yes
- No
- Not sure

69. If you answered "yes" or "not sure," regarding blast injuries, please describe the circumstances of the injury/injuries.

70 Do you take medications for specific medical conditions? If yes, please list the medications and why you take them.

71. **Have you ever suffered a stroke?**

Mark only one oval.

- Yes
- No

72. Were you ever DIAGNOSED with a concussion or head injury during your service? Mark only one oval.

- Yes Skip to question 73.
- No Skip to question 80.

Concussion/Head Injury questions

73. How many concussions/head injuries were you diagnosed with? Please give your age for each.

74. How did you suffer the concussions/head injuries? Check all that apply Mark only one oval.

- Sports or recreational accident (e.g., soccer, biking)
- Motor vehicle accident
- Assault
- Fall that was not sports-related
- Explosion or blast
- Blow to the head (something hit your head
- Other:

75 Please give the context for each concussion(s)/head injury. Describe what happened with each injury and your symptoms. If you lost consciousness, how long were you unconscious?

....

....

....

....

....

76. Who diagnosed the concussions/head injury? Check all that apply.

- ☐ Paramedic
- ☐ Doctor
- ☐ Sports trainer
- ☐ Medic
- ☐ .... Other:

77. If you experienced a loss of consciousness with your concussion(s)/head injuries, how long were you unconscious?

....

....

....

....

....

78. Please select all symptoms you IMMEDIATELY experienced as a result of your concussion/head injury: Check all that apply.

- ☐ Memory Difficulties
- ☐ Attention Difficulties
- ☐ Increased Anxiety
- ☐ Headaches
- ☐ Difficulty Sleeping
- ☐ Changes in Mood
- ☐ ....

Other:

79 Please select all symptoms you feel you STILL experience as a result of your concussion/head injury: Check all that apply.

- [ ] Memory Difficulties
- [ ] Attention Difficulties
- [ ] Increased Anxiety
- [ ] Headaches
- [ ] Difficulty Sleeping
- [ ] Changes in Mood
- [ ] Other: ....

Medical History 2

80. Do you suspect that you sustained one or more UNDIAGNOSED concussion or head injury during your service? Mark only one oval.

- ( ) Yes Skip to question 81.
- ( ) No Skip to question 86.

Undiagnosed Head Injuries

81. How MANY suspected concussions/head injuries have you had? Please give your AGE for each.

....

....

....

....

....

82. What were the circumstances of the suspected concussion/head injury? (Select all that apply) Check all that apply.

- ☐ Sports or recreational accident (e.g., soccer, biking, etc.)
- ☐ Motor vehicle accident
- ☐ Assault
- ☐ Fall that was not sports-related
- ☐ Explosion or blast
- ☐ Blow to the head (something hit your head)
- ☐ Other: ....

83 Please describe what happened with each injury and your symptoms. If you lost consciousness, how long were you unconscious?

....

....

....

....

....

84. Please select all symptoms you IMMEDIATELY experienced as a result of your suspected concussion/head injury: Check all that apply.

- ☐ Memory Difficulties
- ☐ Attention Difficulties
- ☐ Increased Anxiety
- ☐ Headaches
- ☐ Difficulty Sleeping
- ☐ Changes in Mood
- ☐ Other: ....

85. Please select all symptoms you feel you STILL experience as a result of your suspected concussion/head injury: Check all that apply.

- ☐ Memory Difficulties
- ☐ Attention Difficulties
- ☐ Increased Anxiety
- ☐ Headaches
- ☐ Difficulty Sleeping
- ☐ Changes in Mood
- ☐ Other: ....

Medical History 3

86. Do you have any other injuries sustained during your military service? If yes, please describe those injuries.

87 Have you ever been diagnosed with depression? Mark only one oval.

- Yes
- No

88. Have you ever been diagnosed with any of the following: (Select all that apply) Check all that apply.

- [ ] ADHD / Attention Deficit Disorder
- [ ] Dyslexia/dysgraphia
- [ ] Learning Disability
- [ ] Bipolar Disorder
- [ ] Autism/Asperger's
- [ ] Other:

89. Do you have any known medical conditions that could affect your learning or memory performance? If yes, please describe the medical conditions.

90. Compared to your status prior to military service, how do you think your memory ability has changed? Mark only one oval.

- 5 = My memory is much better
- 4 = My memory is somewhat better
- 3 = My memory is about the same
- 2 = My memory is somewhat worse
- 1 = My memory is much worse

91. If you think your memory ability has changed, please describe how it has changed.

92 Compared to your status prior to military service, how has your attention or level of distractibility changed? Mark only one oval.

- 5 = My attention/distractability is much better
- 4 = My attention/distractability is somewhat better
- 3 = My attention/distractability is about the same
- 2 = My attention/distractability is somewhat worse
- 1 = My attention/distractability is much worse

93. If you think your ability to attend/distractibility has changed, please describe how it has changed.

94. Compared to your status prior to military service, how have your anxiety levels changed? Mark only one oval.

- 5 = My anxiety is much lower (much better)
- 4 = My anxiety is somewhat lower (somewhat better)
- 3 = My anxiety is about the same
- 2 = My anxiety is somewhat higher (somewhat worse)
- 1 = My anxiety is much higher (much worse)

95. If you think your anxiety levels have changed, please describe how it has changed.

....

....

....

....

....

96. If you have any specific concerns or comments about your memory, attention, or anxiety, please describe them below:

....

....

....

....

....

Stress and Sleep

97 List THREE life events that were very stressful for you (Events that caused you high levels of stress or anxiety)

....

....

....

....

....

98. In your daily life, what are at least THREE things or situations that cause you stress (things that "stress you out")?

99. **I rate my overall stress level as**

Mark only one oval.

- 1 = very low
- 2 = low
- 3 = moderate
- 4 = high
- 5 = very high

100. Compared to my peers in my classes, my stress level is: Mark only one oval.

- 1 = Much lower
- 2 = Somewhat lower
- 3 = The same
- 4 = Somewhat higher
- 5 = Much higher

101. Compared to other stressful times in my life, my current level of stress is: Mark only one oval.

- 1 = Much lower
- 2 = Somewhat lower
- 3 = The same
- 4 = Somewhat higher
- 5 = Much higher

102 On a typical night, how many hours do you sleep?

103. Please select one statement about your sleeping habits: Mark only one oval.

1 = I usually sleep too much.

2 = I usually get the right amount of sleep.

3 = I usually do not get enough sleep.

104. If you have trouble sleeping, what type of problems do you have? (Select all that apply) Check all that apply.

- Difficulty falling asleep at the beginning of the
- night Difficulty staying asleep (waking up
- during the night) Stressful dreams that disturb
- sleep.
- Sleep

walking Other:

105. How do your sleep problems affect your stress, memory, and attention during the day?

106. **If you would like to find out about** participating in our other studies on memory, attention, and learning in military veteran students, please enter your email address below.

107. If you are experiencing difficulty with memory and/or attention and would be interested in participating in an in-person study on cognitive assessment and treatment, please enter your email address below.

APPENDIX B

BECK DEPRESSION INVENTORY QUESTIONS

Depression Inventory

Please read each group of statements and pick out the ONE statement that best describes the way you have been feeling for the PAST MONTH.

Sadness

0 = I do not feel sad
1= I feel sad much of the time
2 = I am sad all the time
3 = I feel so sad or unhappy that I can't stand it

Pessimism

0 = I am not discouraged about my future
1 = I feel more discouraged about my future than I used to be
2 = I do not expect things to work out for me
3 = I feel my future is hopeless and will only get worse

Past Failure

0 = I do not feel like a failure
1 = I have failed more than I should have
2 = As I look back, I see a lot of failures
3 = I feel I am a total failure as a person

Loss of Pleasure

0 = I get as much pleasure as I ever did from the things I enjoy
1 = I don't enjoy things as much as I used to
2 = I get very little pleasure from the things I used to enjoy
3 = I can't get any pleasure from the things I used to enjoy

Guilty Feelings

0 = I don't feel particularly guilty
1 = I feel guilty over many things I have done or should have done
2 = I feel quite guilty most of the time
3 = I feel guilty all of the time

Punishment Feelings

0 = I don't feel I am being punished
1 = I feel I may be punished
2 = I expect to be punished
3 = I feel I am being punished

Self-Dislike

0 = I feel the same about myself as ever
1 = I have lost confidence in myself
2 = I am disappointed in myself
3 = I dislike myself

Self-Criticalness

0 = I don't criticize myself or blame myself more than usual
1 = I am more critical of myself than I used to be
2 = I criticize myself for all of my faults
3 = I blame myself for everything bad that happens

Suicidal Thoughts or Wishes
0 = I don't have any thoughts of killing myself
1 = I have thoughts of killing myself, but I would not carry them out
2 = I would like to kill myself
3 = I would kill myself if I had the chance

Crying
0 = I don't cry any more than I used to
1 = I cry more than I used to
2 = I cry over every little thing
3 = I feel like crying, but I can't

Agitation
0 = I am no more restless or wound up than usual
1 = I feel more restless or wound up than usual
2 = I am so restless or agitated that it's hard to stay still
3 = I am so restless or agitated that I have to keep moving or doing something

Loss of Interest
0 = I have no lost interest in other people or activities
1 = I am less interested in other people or things than before
2 = I have lost most of my interest in other people or things
3 = It's hard to get interested in anything

Indecisiveness
0 = I make decisions about as well as ever
1 = I find it more difficult to make decisions than usual
2 = I have much greater difficulty in making decisions than I used to
3 = I have trouble making any decisions

Worthlessness
0 = I do not feel I am worthless
1 = I don't consider myself as worthwhile and useful as I used to
2 = I feel more worthless as compared to other people
3 = I feel utterly worthless

Loss of Energy
0 = I have not experienced any change in my sleeping pattern
1a = I sleep somewhat more than usual
1b = I sleep somewhat less than usual
2a = I sleep a lot more than usual
2b = I sleep a lot less than usual
3a = I sleep most of the day
3b = I wake 1=2 hours early and can't get back to sleep

Irritability
0 = I am no more irritable than usual
1 = I am more irritable than usual
2 = I am much more irritable than usual
3 = I am irritable all the time

Changes in Appetite
0 = I have not experienced any change in my appetite
1a = My appetite is somewhat less than usual
1b = My appetite is somewhat more than ususal
2a = My appetite is much less than before
2b = My appetite is much more than before
3a = I have no appetite at all
3b = I crave food all the time

Concentration Difficulty
0 = I can concentrate as well as ever
1 = I can't concentrate as well as usual
2 = It's hard to keep my mind on anything for very long
3 = I find I can't concentrate on anything

Tiredness or Fatigue
0 = I am no more tired than usual
1 = I get more tired and fatigued more easily than usual
2 = I am too tired or fatigued to do a lot of the things I used to do
3 = I am too tired or fatigued to do most of the things I used to do

Loss of Interest in Sex
0 = I have not noticed any recent change in my interest in sex
1 = I am less interested in sex than I used to be
2 = I am much less interested in sex now
3 = I have lost interest in sex completely

APPENDIX C

BECK ANXIETY INVENTORY

Beck Anxiety Inventory

Below is a list of common symptoms of anxiety. Please carefully read each item in the list. Indicate how much you have been bothered by that symptom during the past month, including today, by circling the number in the corresponding space in the column next to each symptom.

	Not At All	Mildly but it didn't bother me much.	Moderately - it wasn't pleasant at times	Severely – it bothered me a lot
Numbness or tingling	0	1	2	3
Feeling hot	0	1	2	3
Wobbliness in legs	0	1	2	3
Unable to relax	0	1	2	3
Fear of worst happening	0	1	2	3
Dizzy or lightheaded	0	1	2	3
Heart pounding/racing	0	1	2	3
Unsteady	0	1	2	3
Terrified or afraid	0	1	2	3
Nervous	0	1	2	3
Feeling of choking	0	1	2	3
Hands trembling	0	1	2	3
Shaky / unsteady	0	1	2	3
Fear of losing control	0	1	2	3
Difficulty in breathing	0	1	2	3
Fear of dying	0	1	2	3
Scared	0	1	2	3
Indigestion	0	1	2	3
Faint / lightheaded	0	1	2	3
Face flushed	0	1	2	3
Hot/cold sweats	0	1	2	3
Column Sum				

***Scoring* -** Sum each column. Then sum the column totals to achieve a grand score. Write that score here ____________ .

APPENDIX D

COHEN PERCEIVED STRESS SCALE

COHEN PERCEIVED STRESS

The following questions ask about your feelings and thoughts during THE PAST MONTH. In each question, you will be asked HOW OFTEN you felt or thought a certain way. Although some of the questions are similar, there are small differences between them and you should treat each one as a separate question. The best approach is to answer fairly quickly. That is, don t try to count up the exact number of times you felt a particular way, but tell me the answer that in general seems the best.

For each statement, please tell me if you have had these thoughts or feelings: never, almost never, sometimes, fairly often, or very often. (Read all answer choices each time)

	Never	Almost Never	Sometimes	Fairly Often	Very Often
B.1. In the past month, how often have you been upset because of something that happened unexpectedly?	0	1	2	3	4
B.2. In the past month, how often have you felt unable to control the important things in your life?	0	1	2	3	4
B.3. In the past month, how often have you felt nervous or stressed?	0	1	2	3	4
B.4. In the past month, how often have you felt confident about your ability to handle personal problems?	0	1	2	3	4
B.5. In the past month, how often have you felt that things were going your way?	0	1	2	3	4

B.6. In the past month, how often have you found that you could not cope with all the things you had to do?	0	1	2	3	4
B.7. In the past month, how often have you been able to control irritations in your life?	0	1	2	3	4
B.8. In the past month, how often have you felt that you were on top of things?	0	1	2	3	4
B.9. In the past month, how often have you been angry because of things that happened that were outside of your control?	0	1	2	3	4
B.10. In the past month, how often have you felt that difficulties were piling up so high that you could not overcome them?	0	1	2	3	4

APPENDIX E

LOGICAL MEMORY CORRECT IDEAS SCORING

(1 point given for each element produced)

Anna

Thompson

South

Boston

Employed as cook

In a school

Cafeteria

(Contacted) Police

(At) Station

Held up

State Street

Night Before

Robbed

56

Dollars

Four

Children

Rent was due

Not eaten

Two days

The police

Touched by the story

Took up a collection

For her

6:00

Monday

Evening/PM

Joe

Garcia

Chicago

Watching TV

As he dressed

To go out

A weather bulletin

Interrupted program

To warn about thunderstorms

Moving into the area/coming

2 or 3

Hours

And remain until morning

The announcer said

The storm could bring hail

4

Inches

Rain

Cause temperature to drop

By 15

Degrees

Joe decided to stay

He took of his coat

He sat down

To watch old movies