THE RELATIONSHIP BETWEEN PRE-DEPLOYMENT INTELLIGENCE AND PTSD IN OEF-OIF VETERANS WITH MILD TRAUMATIC BRAIN INJURY

By

JOSEPH M. GULLETT

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To my loving and beautiful wife, Alice

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I thank my mother, my father, and my Grandmother Loretta for my life and my education. I also thank my mentors Dr. Russell Bauer and Dr. David B. FitzGerald for their continued support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

AOC	Alteration of Consciousness
ANCOVA	Analysis of Covariance
BDI-II	Beck Depression Inventory, 2nd edition
CAPS	Clinician Administered PTSD Scale
DoD	Department of Defense
EF	Executive Functioning
EOD	Explosive Ordinance and Disposal
FSIQ	Full Scale Intelligence Quotient
GED	General Education Development test
GLM	General Linear Model
IQ	Intelligence Quotient
LOC	Loss of Consciousness
MOS	Military Occupation Specialty
mTBI	Mild Traumatic Brain Injury
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
PCL-M	Posttraumatic Checklist, military version
PCS	Postconcussive Symptoms
PTSD	Posttraumatic Stress Disorder
TICV	Total Intracranial Volume
TSI	Time Since Injury
VA	Veterans Administration

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Joseph M. Gullett

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Posttraumatic Stress Disorder (PTSD) is a significant mental health concern for soldiers returning from the wars in Iraq and Afghanistan. There are several known risk factors for the development of PTSD in veterans, such a history of brain injury, younger age at deployment, and a low level of intelligence. Theories of cognitive reserve hypothesize that individuals with lower education and intelligence levels are at greater risk for clinical manifestations of dysfunction following brain injury. To evaluate this hypothesis, pre-deployment military aptitude test results and post-deployment cognitive and mood measures were obtained for 44 male veterans of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) with a history of mild Traumatic Brain Injury (mTBI). We examined whether pre-deployment intellectual ability influenced the development of post-deployment PTSD. Lower pre-deployment intellectual ability was significantly associated with higher reported levels of post-deployment PTSD after controlling for age, head injury frequency, time since injury, and depressive symptom reporting. Utilizing similar controls, low and high pre-deployment intelligence groups differed significantly in their post-deployment executive functioning performance, but increased PTSD reporting was not significantly related to post-combat executive

functioning. However, veterans who experienced a decrease in intellectual functioning performance after deployment reported significantly higher levels of PTSD. These results suggest that lower pre-deployment intelligence can be a risk factor for the development of PTSD in this population, and that coping resources associated with higher order executive functioning may lead to an increased ability to manage the effects of trauma.

CHAPTER 1
INTRODUCTION

Overview

The American Psychiatric Association defines Posttraumatic Stress Disorder (PTSD) as the presence of unwanted intrusive thoughts of a traumatic event, the avoidance of stimuli associated with or numbing of memories from that event, and increased hyper-arousal subsequent to the life-threatening trauma (American Psychiatric Association, 2000). The hostile environment to which deployed soldiers of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) are exposed can be described as a “hotbed” for the development of PTSD symptoms. Prevalence rates of combat-related PTSD in returning OEF/OIF veterans are estimated to fall between 5 and 20% (Hoge et al., 2004; Milliken, Auchterlonie, & Hoge, 2007; Seal, Bertenthal, Miner, Sen, & Marmar, 2007). After returning from foreign wars, veterans with a diagnosis of PTSD are statistically more likely to be unemployed, to experience marital and familial discord, suicidal ideation, substance abuse and dependence, and to encounter problems learning in educational settings (Karney, Ramchand, Osilla, Caldarone, & Burns, 2008). However, not all individuals develop psychological disorders following trauma. There are many risk factors for the development of PTSD, including childhood history of abuse or trauma, family history of psychiatric illness, a lower level of intelligence, and lack of education (Brewin, Andrews, & Valentine, 2000; Charuvastra & Cloitre, 2008; King, King, & Foy, 1996; Macklin et al., 1998).

An individual’s susceptibility to develop PTSD may be increased in those who have experienced direct combat exposure, or who have experienced a mild Traumatic Brain Injury during combat (mTBI; Brenner et al., 2010; Carlson et al., 2010;

Schneiderman, Braver, & Kang, 2008). The prevalence of mTBI (as opposed to death or more severe injury) has increased in recent wars as a result of improved body armor and advanced medical care, which has led to an increase in the wounded-to-killed ratio. In response to this increase in prevalence, researchers have sought to determine factors which "protect" an individual from the long-lasting effects of brain injury. This protective factor is often referred to as cognitive reserve, or the capacity of an individual's brain to resist or overcome the effects of trauma and reduce the presence of dysfunction following an injury. Many studies have supported the theory of cognitive reserve, which hypothesizes that a combination of intellectual ability and level of education serve as a protective factor against the development of cognitive dysfunction subsequent to neurologic disease or injury (Fay et al., 2010; Helmstaedter & Kockelmann, 2006; Kesler, Adams, Blasey, & Bigler, 2003; Scarmeas et al., 2003).

PTSD Risk Factors

PTSD is a major public health concern, and understanding the factors that influence its development is crucial for prevention and treatment efforts. It is estimated that the lifetime prevalence of PTSD in trauma-exposed individuals is as high as 24%, and as high as 9% in the general population (Feeny & Foa, 2005). The prevalence rate of PTSD in OIF/OEF veterans has been estimated to fall between 5% and 20%, which is roughly three to four times the prevalence in the general U.S. population (Hoge et al., 2004; Seal et al., 2007). Furthermore, a recent large scale study of OIF/OEF veterans showed that incurring a mTBI doubles the risk for the development of PTSD (Schneiderman et al., 2008). Several factors intrinsic to the individual and their home environment can increase the risk of developing PTSD as a result of exposure to combat in a wartime situation, such as a family history of psychiatric illness, childhood abuse and/or adversity, previous trauma history, lower intelligence, lack of education, and younger age at traumatic exposure (Brewin et al., 2000; Charuvastra & Cloitre, 2008; King et al., 1996; Macklin et al., 1998). However, the factors present at the time of the trauma, or even afterward, are better predictors of the development of PTSD. These factors include concomitant life stressors, lack of social support, intelligence level, and trauma severity (Brewin et al., 2000; McNally & Shin, 1995). There may even be a selection bias that predisposes military populations to develop psychiatric conditions at an increased rate after deployment, as one report found higher rates of reported childhood physical and sexual abuse in military populations (Seifert, Polusny, & Murdoch, 2011). In military veterans exposed to wartime atrocities such as the death of comrades, brutal killing of men, women, and children, and the constant threat of attack resulting in bodily injury; the presence of risk factors pre-deployment can significantly increase the likelihood of developing PTSD. Therefore, the identification of known risk factors in military populations is a critical step in prevention efforts.

Cognitive Theories of PTSD

Cognitive theories of emotion propose that a person's interpretation of a life-threatening event is more important than the event itself in determining the person's emotional and behavioral reaction (Feeny & Foa, 2005). One recent study examined the cognitive factors related to preparedness for war and the perception of threat in 207 OEF/OIF veterans. The author found that the effect of a soldier's combat experience on the development of PTSD was highly dependent upon how that individual perceived threats in their environment (Renshaw, 2011). Interestingly, some soldiers received specialized training prior to deployment which was intended to prepare them for the combat experiences they might encounter. This study found that this level of "preparedness for war" was a significant moderator for how perceptions of threat related to PTSD levels. In other words, those veterans who reported being more psychologically prepared for war had levels of threat perception which matched their actual level of combat experience, whereas those soldiers who reported being unprepared for war had high levels of threat perception regardless of their combat experience. This suggests that there may be a need for a pre-deployment psychological intervention to better prepare soldiers for wartime combat situations. It also raises the question as to whether soldiers with more limited cognitive capacity prior to deployment are at increased risk for the development of PTSD due to decreased coping abilities.

Another cognitive theory of stress reaction has sought to integrate the effect that environmental and cognitive variables have on emotional outcomes in response to stress. Hobfoll proposed that the threat of the loss of one's resources is the main factor that drives the development of stress disorders (Hobfoll, 1989). The author defines resources as personal characteristics (e.g. self-esteem), objects (e.g. a home or car), energies (e.g. time and money) and conditions (e.g. marriage) that a person obtains over their lifetime. Those individuals who are exposed to stressors or experience a trauma perceive that this event has threatened their cache of resources, resulting in a negative psychological reaction. When conceptualizing the development of PTSD in this context, it becomes clear how individuals who are deployed to war, thousands of miles from nearly all of their resources, are at an increased susceptibility to developing stress reactions in response to their perceived loss of resources. Because one's intellectual ability is a general factor representative of the collective of experiences and resources obtained over the course of the lifespan, those with fewer resources upon deployment to war (i.e., those with lower pre-deployment intelligence) are likely to be susceptible to the development of a stress-disorder such as PTSD.

Cognitive Reserve

Much like the theory of conservation of resources proposed, several theorists and researchers sought to describe cognitive reserve as a resource which can bolster an individual against the effects of a trauma. In the passive model of brain reserve capacity proposed by Satz, the cognitive sequelae of a brain injury would be manifested in an individual once the magnitude of injury reached that individual's inherent threshold (Satz, 1993). Using a more active, neurobehavioral model of cognitive reserve, Stern postulated that the brain of an individual with high levels of education and IQ actively attempts to compensate for injury in a greater, more efficient manner than that of an individual with lower levels of education and IQ. This theory suggests that through reorganization of damaged neural networks, the brain is able to recruit networks previously unused for that particular cognitive process prior to injury (Stern, 2002). Whether cognitive reserve exists as an active or passive process has yet to be definitively proven through research. The common threads tying investigations of such theories together, however, appear to be that the experiences (education) and abilities (intelligence) of affected individuals are consistently associated with cognitive performance and pathology following injury.

A hallmark study in 1968 first proposed the concept of a cognitive reserve threshold in aging humans with dementia (Blessed, Tomlinson, & Roth, 1968). These researchers found that objective evidence of neurocognitive dementia symptom onset was not present in elderly individuals until damage to the brain reached 50-100cc of volume, as measured by the sum of brain infarctions present on post-mortem histological examination. In the years to follow, many research studies have tested and supported the cognitive reserve hypothesis with brain injured populations. Kesler and colleagues examined education and pre-injury IQ as factors related to Total Intracranial (brain) Volume (TICV) and change in IQ following brain injury in a civilian population. The authors found that TICV was highly correlated with IQ, suggesting that those with higher TICV measurements had a higher level of brain reserve. They also found that decreases in post-injury IQ from pre-injury IQ were significantly greater for the low-IQ group (FSIQ <90), suggesting that loss of function was greater in those with lower pre-injury reserve (Kesler et al., 2003).

More recently, a longitudinal study of children and adolescents with mTBI confirmed the hypothesis that higher cognitive reserve, as measured by cognitive testing, is related to the presence of fewer Postconcussive Symptoms (PCS) following injury (Fay et al., 2010). In the most technologically sophisticated investigation of cognitive reserve to date, Haute and colleagues investigated how Cognitive Capacity related to the organizational quality of white matter in the brains of young persons. The authors defined Cognitive Capacity as a composite of WASI-III FSIQ, achievement testing scores, and years of education. The structural quality of brain white matter was measured using Diffusion Tensor Imaging (DTI). They found that directional organization of white matter fibers was positively correlated with Cognitive Capacity after correcting for multiple comparisons, once again implicating the existence of a brain reserve related to an individual’s intelligence and education levels (Haut et al., 2007).

Many researchers and theorists have suggested that an individual’s acquired years of education is a meaningful and easily obtained proxy for Cognitive Reserve

(Katzman, 1993). However, in a military population such as the one in the present study, this postulate may prove difficult as the overwhelming majority of individuals were deployed to combat with a high school diploma or GED equivalent, and thus exhibit little variability in their level of education as a group. Therefore, a pre-morbid measure of intelligence would serve as the most appropriate measure of cognitive reserve in this population.

The Relationship between Intelligence and PTSD

Given the fact that an individual's experiences throughout their lifespan influence the level of intelligence they possess, it seems likely that the mental qualities afforded to persons with higher intelligence, such as coping skills, can assist in diffusing the effects of trauma. A recent meta-analysis found a small mean effect size (r=.18) for the relationship between intelligence and PTSD based on six studies with 1,149 participants (Brewin et al., 2000). The relationship of intelligence as a protective factor for PTSD has been supported in numerous studies (Gale et al., 2008; Gil, Calev, Greenberg, Kugelmass, & et al., 1990; Gilbertson, Gurvits, Lasko, Orr, & Pitman, 2001; Kremen et al., 2007; Pitman, Orr, Lowenhagen, Macklin, & Altman, 1991; Vasterling, Brailey, Constans, Borges, & et al., 1997; Vasterling et al., 2002), and even in some studies after controlling for combat exposure (Macklin et al., 1998; McNally & Shin, 1995; Wright, Cabrera, Eckford, Adler, & Bliese, 2012). Despite this abundance of research, little is known about specific cognitive factors that influence the relationship between pre-deployment intelligence as protective for post-deployment emotional dysfunction after the occurrence of blast-related mTBI.

Individuals with lower global intelligence as measured by currently available intelligence measures may also exhibit weaker performance on tests of executive functioning. Executive functioning refers to a set of complex, higher-order, goal-driven mental processes, including inhibition, planning, problem solving, initiation, cognitive flexibility, and self-monitoring (Lezak, Howieson, Loring, Hannay, & Fischer, 2004; Stuss & Alexander, 2000). One could reason that individuals with impairment in their ability to self-monitor and problem solve as a result of lowered executive functioning ability may be at an increased risk for the development of psychological disorders. Therefore, evaluating this component of mental functioning may provide important insight to the source of psychological dysfunction, as well as a potential area of intervention in those who are identified as being at risk.

The Occurrence of Co-morbid Depression & PTSD Post-deployment

Individuals diagnosed with PTSD in the general population are at an increased risk of developing co-morbid conditions, such as depression. In fact, the National Comorbidity Study found that 88 percent of men and 79 percent of women who were diagnosed with PTSD had also been given another psychiatric diagnosis at some point in their lifetime (Kessler, Sonnega, Bromet, Hughes, & et al., 1995). More germane to the current study, one investigation found that two thirds of soldiers returning from the wars in Iraq and Afghanistan have been found to have co-morbid PTSD and depression (Karney et al., 2008), while other studies report comorbidities between 3.6% and 6.3% (Grieger et al., 2006; Schell & Marshall, 2008). The diagnostic criteria for the two diagnoses are similar, with both requiring the presence of some combination of vegetative symptoms (increased or decreased sleep), numbing of emotions, loss of interest, anhedonia, restricted range of affect, irritability, anger, and difficulty concentrating. With this in mind, some degree of comorbidity in research studies involving combat-exposed populations is inevitable. Therefore, in studies which seek to examine the effect of various factors on the development of PTSD, the presence of depressive symptoms is a factor that must be strongly considered before making theoretical or statistical conclusions.

Co-occurring PTSD and mTBI

Evidence that PTSD and mTBI can exist jointly is becoming increasingly abundant. A diagnosis of PTSD requires that a life-threatening trauma (or the perception thereof) must have been experienced, and the re-experiencing of that event is a central component of the disorder. According to the Veterans Administration (VA) and Department of Defense (DoD), a diagnosis of mTBI is based upon the experience of a trauma-event significant enough to produce a Loss of Consciousness (LOC) less than 30 minutes, Alteration of Consciousness (AOC; i.e., feeling dazed, “seeing stars”, or becoming momentarily disoriented) less than 24 hours, with posttraumatic amnesia for the event equaling less than 24 hours in duration (VA/DoD, 2009). In light of these diagnostic criteria, some have argued that if a person is rendered unconscious and has amnesia for the event, they cannot truly develop PTSD. However, soldiers in the current wars in Iraq and Afghanistan often experience several instances of mTBI in theater, many of which are characterized strictly by AOC, means that the two disorders can be produced simultaneously. Furthermore, many of the experiences of these soldiers, such as the loss of a close friend in combat, occur independently of the events that produced mTBI in combat. As such, the veterans returning from these wars are at an increased risk for both PTSD and mTBI. Delineating the factors that affect the two phenomena is crucial to understanding their development.

Time Since Injury and Age at Injury

In an extensive review of the neuropsychological sequelae of PTSD and TBI in OEF/OIF veterans, Dolan argued that accounting for Time Since Injury (TSI) and severity of TBI is crucial for researchers in who wish to make assumptions regarding the presence of neuropsychological and emotional dysfunction in brain injured veteran populations (Dolan et al., 2012). One study suggests there may be evidence that a younger age at injury is a factor that interacts with increased TSI to produce higher rates of post-injury psychological symptom reporting (Senathi-Raja, Ponsford, & Schonberger, 2010). Another study determined that longer TSI in soldiers with PTSD was associated with reduced attentional abilities on neuropsychological investigation, and that age at injury was not a factor which affected the cognitive outcomes (Marx et al., 2009). In light of the mixed findings in this area, considerable attention will be paid to TSI in the present study in order to account for the effects it may have on the generalizability of findings to the entire veteran population.

Military Rank, Military Occupation Specialty, & Loss of Consciousness

Several research studies have determined that combat exposure is significantly related to PTSD symptom reporting and experiencing mTBI in veterans returning from Iraq and Afghanistan (Karney et al., 2008; Tanielian, Jaycox, Schell, Marshall, & Vaiana, 2008). A soldier's combat exposure may possibly be related to their Military Operation Specialty (MOS). As one might expect, an Information Technology specialist is likely to have less combat exposure than an Explosive Ordinance and Disposal (EOD) technician, and in turn, fewer instances of LOC and AOC. Due to the complexity of the MOS system and the wide variability present in this sample, MOS was not included as a possible confounding variable in the current study. As mentioned previously, soldiers who experience mTBI develop PTSD at nearly double the rate of those who did not report experiencing mild TBI (Schneiderman et al., 2008). Therefore, the number of reported LOC or AOC would serve as an appropriate proxy for combat exposure in this population.

While research demonstrates a clear association between pre-deployment ability and post-deployment psychological outcomes, little is known about the applicability of these findings to individuals deployed to the Iraq and Afghanistan conflicts. The soldiers returning from these wars are experiencing unprecedented rates of survival after brain injury as a result of recent technological advances (e.g. Kevlar body armor), and as a result, a neuropsychologically unique population has arisen. Little is known about how the pre-deployment experiences of these soldiers affect their post-deployment cognitive and emotional outcomes, and whether or not there exists a component of cognitive functioning that can be altered to reduce psychological dysfunction post-war. We hypothesize that the negative association between pre-deployment intellectual ability and post-deployment psychological dysfunction seen in previous research will hold true in the current population. Additionally, we aim to identify a cognitive construct which can not only explain the variability between individuals with and without dysfunction post war, but which can also be a source of intervention for those who are at risk for the development of such dysfunction.

CHAPTER 2
METHODS

Participants

Participants were recruited as part of a larger neuroimaging study of the effects of blast-related mTBI on the white matter of the brain (VA RR&D Grant # B6698W). To be included in the imaging study, participants must have experienced an alteration or loss of consciousness as a direct result of a blast while on active duty in Iraq or Afghanistan. Participants were excluded if they had a self-reported or medically documented history of substance abuse (e.g. alcohol), neurological conditions (e.g. epilepsy), and brain abnormalities (e.g. tumor, stroke, visible white matter abnormalities). The presence of these criteria was established first through self-report, neurological examination by the attending study physician (DBF), followed by medical record confirmation of known conditions. Participant accounts of their blast history were also confirmed through medical record review, where possible. All participants were required to be MRI safe, and must have passed the implicit or embedded effort measures given as part of a full length neuropsychological battery administered by a trained psychometrician according to a standardized protocol. As the neuropsychological tests employed in this study utilize native English speaking normative samples, participants must also have been native English speakers. This requirement avoided the possibility of confounding results of the neuropsychological test interpretation, especially on language and verbal memory based tests.

Those who were included in the study were retrospectively contacted after their initial participation by the primary author (JMG) in order to obtain written consent to collect ASVAB scores (which serve as a proxy for general intellectual ability; see below) from the Department of Defense. Of the 54 eligible participants in the larger study, 44 respondents gave written consent to collect ASVAB data, and were included in the final analysis for the current study. The participant population was comprised of 44 enlisted male OEF/OIF veterans with an age range of 24 to 49 (m: 32.02, SD: 5.77) and an average education level of 12.11 years (SD: .935). Females were not specifically excluded; however those few who did qualify and participated in the study were later disqualified as a result of exclusionary criteria discoveries (e.g. brain abnormalities, failed effort testing). A breakdown of all demographic variables is included in Table 2-1.

Cognitive Measures

The Armed Services Vocational Aptitude Battery (ASVAB) is administered to all military personnel prior to enlistment either in pencil-and-paper fashion, or as a Computerized Adaptive Test (CAT). As such, it is not administered to those who enter the military as officers. The results of the ASVAB are used, "in conjunction with other criteria for the selection of applicants for enlistment into the Armed Forces and the classification of those accepted as recruits (Brannick, 1990, p. 16)." The ASVAB is comprised of several subtests that are combined to create composite scores, such as the Armed Forces Qualification Test (AFQT) and the General Technical (GT) score. The AFQT composite is a percentile score that is used by all four main branches of the U.S. military to "provide a measure of general trainability of applicants accepted for enlistment" (Brannick, 1990, p. 24).

Because of the academic nature of the subtests comprising the AFQT, including Arithmetic Reasoning, Paragraph Comprehension, Word Knowledge, and Mathematics Knowledge; its utility as a measure of IQ has been evaluated by several researchers. The AFQT has been determined to be as psychometrically sound as any widely available IQ measure at predicting general factors of intelligence, and in most cases, it performs better (Herrnstein & Murray, 1994). Herrnstein and Murray (1994) demonstrated that in multivariate analyses of both military populations and participants from the National Longitudinal Survey of Youth (NLSY), the AFQT consistently correlated higher with other measures of intelligence more than those other measures of intelligence did with one another. Other researchers have found that the AFQT was strongly associated with crystallized measures of intelligence, predicting as much as 32% of the variance in WAIS-III Vocabulary and Information scores, WRAT-3 Reading ability, and NAART Full Scale IQ. Additionally, the AFQT was partially associated with several fluid measures of intelligence (WAIS-III Digit Symbol Coding and Block Design, Trails B; Kennedy, Kupke, & Smith, 2000; Poppen & Southwell, 2003), which explained 20% of the variance in AFQT scores. Another group of researchers also found the AFQT subscale of the ASVAB to correlate very highly (r=.92) with the Multidimensional Aptitude Battery (MAB), an instrument used to measure intelligence very similar to the WAIS. The authors created a regression equation that allowed them to reliably predict a person's MAB Full Scale IQ from their ASVAB AFQT score (Orme, Brehm, & Ree, 2001). Thus, several research investigations have determined that the AFQT serves very well as a measure of pre-morbid intelligence in soldiers needing to undergo a neuropsychological evaluation in the Veterans Affairs system.

Several neuropsychological measures were administered to participants as part of the larger study. The National Adult Reading Test (NART; Nelson, 1982) is a 50-item word list widely used in practice and research in order to estimate pre-morbid intellectual ability. It has been found to correlate highly with traditional neuropsychological measures of IQ, such as the WAIS-III and WAIS-R (Crawford, Parker, Stewart, & Besson, 1989; Mathias, Bowden, & Barrett-Woodbridge, 2007; Willshire, Kinsella, & Prior, 1991), and has even been shown to accurately predict pre-injury IQ after head injury (Moss & Dowd, 1991). As this test is predominantly based upon verbal skills, its ability to predict pre-morbid intelligence may be limited to instances in which it is compared to a measure with a verbal component, such as the AFQT.

Another test which participants in the larger study received was the Adaptive Digit Ordering Test (DOT-A). This test requires participants to organize a list of seven randomly presented digits into increasing order. Research on the DOT-A has determined that this test is sensitive to frontal lobe dysfunction in patients with Parkinson's disease as well as frontal lobe damage (Werheid et al., 2002). Additionally, participants were administered the Trail Making Tests (TMT-A, TMT-B; Reitan, 1958) according to standard administration procedures. Of particular interest for the current study was TMT-B, which has been found to be particularly sensitive to frontal executive dysfunction in a wide variety of populations (Arbuthnott & Frank, 2000; Periáñez et al., 2007; Stuss et al., 2001). Lastly, the Controlled Oral Word Association Test (Benton, 1967) was administered to participants in standardized fashion. While the test was originally designed to assess verbal fluency in aphasia, research has determined that frontal lobe functioning plays a large role in the ability of patients to perform this task (Brooks, Fos, Greve, & Hammond, 1999; Raskin, Mateer, & Tweeten, 1998; Raskin & Rearick, 1996).

Self-Report Measures

The Posttraumatic Checklist Military (PCL-M) is a 17-item self-report measure used by researchers and clinicians to assess the likelihood in which problems and complaints associated with PTSD are present in military populations. The PCL-M has been validated with the Structured Clinical Interview for the DSM-IV-TR (SCID), and has been reported to have high test-retest reliability, internal consistency, and convergent and discriminant validity (Bliese et al., 2008; Pratt, Brief, & Keane, 2006).

The PCL-M is based on the criteria for diagnosing PTSD set forth in the DSM-IV (Weathers, Huska, & Keane, 1991), however the specific scoring method for diagnosing PTSD with this instrument varies across research studies. Using the symptom-cluster method of scoring the PCL-M (Brewin, 2005), a diagnosis of PTSD may be warranted in participants who endorse a symptom rating of 3 out of 5 on at least one re-experiencing symptom, two arousal symptoms, and three avoidance symptoms (Weathers & Ford, 1996). This particular scoring method has produces a sensitivity of 1.00 and specificity of 0.92, signifying that all cases of PTSD were correctly identified and eight percent of cases were misdiagnosed as having the disorder (Manne, Du Hamel, Gallelli, Sorgen, & Redd, 1998). Another method used to identify cases of PTSD using the PCL-M involves totaling the responses for all 17 items, and identifying cases of PTSD as those who scored over 50 (Andrykowski, Cordova, Studts, & Miller, 1998; Weathers & Ford, 1996). This scoring method, while less involved than the method previously described, has slightly higher specificity (0.99) but lower sensitivity (0.60) and tends to lack the PTSD identification ability of the symptom-cluster method. All participants in the current study had been given a clinical diagnosis of PTSD in the Veterans Affairs system prior to inclusion. For the purposes of regression analyses in this study, the PCL-M total score was utilized as a continuous variable, with no cut-off scores or individual response criteria being applied. When performing group based comparisons, various methods were examined for their ability to classify participants with PTSD. In the current study, the PCL-M possessed high internal consistency with Cronbach's alpha equal to 0.94.

The Beck Depression Inventory, 2nd Edition (BDI-II), is a self-report measure used to assess depressive symptoms in adults (Beck, Steer, & Brown, 1996). The BDI-II is comprised of 21 items related to depressive symptoms that correspond to the diagnostic criteria for depression listed in the DSM-IV. The BDI-II has been validated with the Structured Clinical Interview for DSM-IV (SCID; Sprinkle et al., 2002) and has been shown to have strong reliability in clinical populations (Ambrosini, Metz, Bianchi, & Rabinovich, 1991; Storch, Roberti, & Roth, 2004). High levels of PTSD and depressive symptoms have been reported in populations returning from Iraq and Afghanistan (Ramchand, Karney, Osilla, Burns, & Caldarone, 2008), therefore this measure has been included to determine the extent to which the two psychological phenomena can be independently accounted for in the current study. In this study, the BDI-II demonstrated high internal consistency with Cronbach's alpha of 0.94.

Procedure

Statistical analyses were performed using IBM SPSS Statistics v20.0 statistical software. A linear regression was performed to determine the amount of variance in PTSD symptom reporting that could be accounted for by pre-deployment intellectual ability as measured by the AFQT percentile score, controlling for age and frequency of head injury during combat. As the AFQT score is highly correlated to general intellectual ability, education was not controlled for as it is presumed to be a proxy of intelligence. Furthermore, given that the acquired level of education in this sample had a highly modal distribution (12 years); this variable was proven in a cursory analysis to be statistically unsuitable as a controlling variable due to its highly kurtotic nature.

Composite variables have been found to be more stable and reliable representations of a cognitive construct, specifically Executive Functioning (EF; Salthouse, Atkinson, & Berish, 2003). According to Salthouse and colleagues, the creation of a composite variable serves to simplify analyses by “allowing variables with different units of measurement to be analyzed simultaneously.” This procedure additionally allows for the reduction of variables introduced into the statistical model, which is important in studies with a relatively small number of participants. In the current study, three cognitive variables (TMT-B, COWAT, and DOT-A) designed to measure EF performance were highly correlated with one another, thus suggesting they measured the same cognitive construct. An EF composite score was created in *SPSS* by computing z-scores for each participant on each of the three tests, and averaging these z-scores. For the purposes of psychometric consistency within this composite creation procedure, TMT-B elapsed time scores were inverted so that the participant with the longest elapsed time to completion in this sample had the lowest score, and vice versa.

High and low intelligence groups were created using a mean-split procedure in which veterans with AFQT percentile scores at or above the mean for the sample were assigned a value of 1, and those with AFQT percentile scores below the mean were assigned a value of 0. For the participants in the study who had complete data, this procedure resulted in one group of 22 veterans at or above the mean, and another group of 22 veterans below the mean of the entire sample. Utilizing the EF composite variable, Analysis of Covariance (ANCOVA) was performed to determine whether participants with high versus low AFQT scores varied in their EF performance after controlling for demographic variables thought to affect EF, such as age and the presence of LOC. It should be noted that two veterans in the sample did not have complete data for the neuropsychological battery and were therefore excluded from analyses involving the EF composite. Statistical investigation of these two participants revealed that they were Missing Completely at Random (MCAR), meaning their missingness was not related to a statistically identifiable factor (Little's MCAR chi-square = 2.537, df = 1, p = .11). Therefore, these missing participants' exclusion was not likely to affect the validity of analyses.

Table 2-1. Participant demographics (N = 44)

	Mean	Standard Deviation
Age [a]	32.02	5.77
Time since Injury [b]	4.60	2.07
Education [c]	12.11	.935
LOC [d]	1.11	1.21
AOC [d]	3.33	3.24
AFQT	61.17	20.00
PCL-M [e]	56.50	15.89
BDI-II	23.31	12.58
EF Composite [f]	0.00	0.80

Note. All participants were classified as incurring at least one mild Traumatic Brain Injury (AOC or LOC). [a] Current. [b] Years. [c] Completed years at deployment. [d] Frequency. [e] Percentile. [f] N = 42

CHAPTER 3
RESULTS

All examined variables in the current dataset met General Linear Model (GLM) normality requirements for skewness and kurtosis. For all ANCOVA analyses, Levene's test for the inequality of variances was non-significant, confirming that the GLM assumption held true. Additionally, factor interaction models were tested for each GLM based analysis to confirm the homogeneity of regression assumption.

In order to determine whether the AFQT could be used as a valid measure of pre-morbid intellectual ability in this sample, Pearson correlations were performed to compare participants' pre-deployment intelligence (AFQT) to their post-deployment pre-morbid intelligence estimate (NART). Results indicate that the AFQT was highly correlated with post-deployment NART scores ($r[44] = 0.67$, $p<.01$; Table 3-1). Given that the psychometric properties of these two intelligence tests are very distinct, this strong positive relationship should not be over-interpreted to imply the absence or presence of change in intelligence post-deployment. To evaluate such changes, a difference score was created by putting the scores from these two intelligence estimates into a common z-score metric and subtracting post-deployment from pre-deployment z-scores. This procedure results in an IQ change score, which could in turn be used to examine the hypothesis of whether reported PTSD symptoms are associated with a decline in intellectual ability (Macklin et al., 1998).

A linear regression was employed to examine whether a relationship existed between IQ change scores and PTSD reporting. Careful consideration of correlational analyses revealed a strong positive statistical relationship between reported levels of PTSD on the PCL-M and depression on the BDI-II ($r[44] = 0.64$, $p<.01$; Table 3-1). By controlling for depressive symptoms in this regression model, the unique contribution of IQ change to PTSD beyond that of reported depression was examined. A proxy of combat exposure (LOC) was also included as a controlling variable in this model as combat exposure was thought to have a positive linear relationship to the presence of PTSD. Additionally, age and Time Since Injury were controlled for in this analysis. Results indicate a strong relationship between IQ change scores and PTSD symptom reporting [$F(5,43)=7.89$, $p < .001$], with the overall model accounting for 51.0% of the variance in symptoms. The direction of this relationship was such that those veterans who reported higher levels of PTSD experienced larger declines in IQ score. More specifically, for each standard deviation reduction in the IQ change z-score, veterans scored 5.07 points higher on the PCL-M. The results of this analysis suggest that the prolonged presence of PTSD post-combat was related to a relative reduction in intellectual functioning as measured by these two IQ estimates (See Table 3-2).

An additional linear regression examined whether the AFQT could be used to account for post-deployment PTSD reporting on the PCL-M. As previously mentioned, a strong positive relationship existed between PTSD and depressive symptom reporting in the current sample data, and the unique contribution of PTSD beyond that of depression was examined in this regression model. Results indicate that the AFQT accounted for an additional 12% of unique variance in PTSD reporting after controlling for age, TSI, LOC frequency, and depressive symptom reporting. The addition of the AFQT in step three of the regression model resulted in a highly significant F-change over step two [$F(1,38) = 10.89$, $p = .002$]. The full model exceeded the specified .05 significance level, $F(5,38) = 10.1$, $p = .000$, and explained 57% of the total variance in

PTSD reporting on the PCL-M in this sample. It was found that the AFQT significantly predicted reported levels of PTSD such that those with lower AFQT scores tended to report higher levels of PTSD ($\beta = -.38$, $p<.01$). Examination of unstandardized beta coefficients revealed that for each percentile decrease in AFQT score, a three point increase in PTSD was reported on the PCL-M after accounting for controlling variables. Additionally, BDI-II depression reporting significantly predicted PTSD such that those reporting higher depression also reported higher PTSD ($\beta = .70$, $p<.01$). For each one point increase in PTSD reported, nearly a full point increase in BDI-II depression reporting was observed upon examination of beta coefficients in this model (See Table 3-3).

Full-factorial ANCOVA was employed to determine whether veterans with below average pre-deployment intelligence differed from those with above average pre-deployment intelligence in their post-deployment EF composite scores. By controlling for the variables age and frequency of LOC, the ability of the AFQT to predict unique variance in PTSD reporting was examined in the context of participants' EF performance. The results described in Table 3-4 show that low and high intelligence groups significantly differed in the EF composite scores, indicating a significant main effect for pre-deployment intelligence level after controlling for age and frequency of LOC [$F(1,39) = 4.28$, $p<.05$, $\eta p^2 = .10$]. The age covariate was not significantly related to EF [$F(1, 39) = 1.85$, $p>.05$, $\eta p^2 = .05$], nor was frequency of LOC [$F(1,39) = 0.01$, $p>.05$, $\eta p^2 = .00$]. Planned contrasts further confirmed that veterans having below mean intelligence had significantly lower EF composite scores [p=.045, 95% CI (-1.20, -0.01)] compared to veterans with above mean intelligence. Consideration of post-hoc ANOVA results revealed that the EF composite scores of the below average intelligence group ($M = -0.32$, $SD = 0.86$) were significantly lower than the above average intelligence group ($M = 0.31$, $SD = 1.05$). It is important to note that the EF composite correlated significantly with the pre-deployment IQ estimate (AFQT; $r[42]=.41$, $p=.008$) and with the post-deployment pre-morbid IQ estimate (NART; $r[42]=.54$, $p=.000$), and this relationship was stronger than that of the individual components of the EF composite (See Table 3-1). This suggests that the EF composite may represent a strong cognitive construct which is a bi-product of intellectual functioning itself.

Given the association between EF and pre-deployment intelligence on the AFQT, a linear regression was performed to determine whether current EF performance is associated with PTSD above and beyond that which can be attributed to pre-deployment intelligence. By controlling for pre-morbid intellectual ability on the AFQT, the association between current EF and PTSD was examined to determine if prolonged exposure to PTSD symptoms was related to EF performance. The full model exceeded the .05 significance level, $F(6, 41) = 8.45$, $p < .001$, and explained 59.2% of the total variance in PTSD symptom reporting. However, the significance of this model can be solely attributed to the association between the AFQT and PTSD reporting, as EF did not provide a significant contribution in explained variance in PTSD symptoms above and beyond that of the AFQT. The results of this analysis suggest that prolonged presence of PTSD symptoms post-combat is not related to EF performance (See Table 3-5).

Table 3-1. Intercorrelations between cognitive and emotional functioning measures for veterans (N = 44)

Measure	1	2	3	4	5	6	7	8
1. PCL-M	-	.64**	-.38*	-.12	-.10	-.09	.10	-.14
2. BDI-II	.64**	-	-.10	-.12	-.28	.03	.16	-.26
3. AFQT	-.38*	-.10	-	.28	.34*	.67**	.32*	.41**
4. COWA [a]	-.12	-.12	.28	-	.38*	.32*	-.37*	.74**
5. DOT-A [a]	-.10	-.28	.34*	.38*	-	.49**	-.47**	.79**
6. NART [a]	-.09	.03	.67**	.32*	.49**	-	-.46**	.54**
7. TMT-B [ab]	.10	.16	.32*	-.37*	-.47**	-.46**	-	-.79**
8. EF composite [a]	-.14	-.26	.41**	.74**	.79**	.54**	-.79**	-

[a] N=42, [b] Scores recorded as total time elapsed to completion. *$p < .05$. **$p < .01$.

Table 3-2. Summary of regression analysis for IQ change score predicting PTSD reporting in veterans (N=44)

	Variable	B	SE B	β
Step 1				
	Age	0.06	0.38	0.02
	Time Since Injury	-0.25	0.94	-0.03
	LOC	2.41	1.65	0.18
	BDI-II	0.78	0.16	0.62**
Step 2				
	Age	0.00	0.37	0.00
	Time Since Injury	-0.70	0.92	-0.09
	LOC	2.05	1.59	0.16
	BDI-II	0.74	0.16	0.59**
	IQ Change	-5.07	2.31	-0.26*

Note. $R^2 = .45$ for Step 1; $\Delta R^2 = .51$ for Step 2 (ps < .05). IQ Change is the NART z-score subtracted from the AFQT z-score. *p < .05. **p < .01.

Table 3-3. Summary of regression analysis for AFQT predicting PTSD reporting in veterans (N = 44)

	Variable	B	SE B	β
Step 1				
	Age [a]	0.76	0.44	0.27
	LOC [b]	4.07	2.01	0.31*
	Time since Injury [c]	-0.44	1.17	-0.06
Step 2				
	Age [a]	0.06	0.38	0.02
	LOC [b]	2.41	1.65	0.18
	Time since Injury [c]	-0.25	0.94	-0.03
	BDI-II	.784	.164	0.62**
Step 3				
	Age [a]	-0.99	0.34	-0.04
	LOC [b]	2.22	1.48	0.17
	Time since Injury [c]	-1.18	0.89	-0.16
	BDI-II	0.77	0.15	0.70**
	AFQT	-0.30	0.09	-0.38**

Note. $R^2 = .13$ for Step 1; $\Delta R^2 = .32$ for Step 2 (ps < .01); $\Delta R^2 = .12$ for Step 3 (ps < .05).
[a] Current. [b] Frequency. [c] Years *p < .05. **p < .01.

Table 3-4. Analysis of covariance for differences in executive functioning by AFQT (N=44)

	Executive Functioning Composite Score			
Variable	df	F	ηp^2	p
Age [a]	1	1.85	0.05	.18
LOC [b]	1	0.00	0.00	.96
AFQT				
<mean vs. ≥ mean	1	4.28*	0.10	.04
Error	39	(36.04)		

[a] Current, [b] Frequency

Table 3-5. Summary of regression analysis for executive functioning composite predicting PTSD reporting in veterans (N=42)

	Variable	B	SE B	β
Step 1				
	Age	0.07	0.40	0.02
	Time Since Injury [a]	-0.22	0.99	-0.03
	LOC [b]	2.37	1.71	0.18
	BDI-II	0.79	0.17	0.62**
Step 2				
	Age	-0.08	0.35	-0.03
	Time Since Injury [a]	-1.09	0.93	-0.14
	LOC [b]	1.99	1.51	0.15
	BDI-II	0.81	0.15	0.64**
	AFQT	-0.35	0.10	-0.44**
	EF Composite	-2.44	1.98	-0.15

Note. R^2 = .45 for Step 1; ΔR^2 = .59 for Step 2 (ps < .01). EF composite is for TMT-B, COWAT, and DOT-A. [a] Years. [b] Frequency. *p < .05. **p < .01.

CHAPTER 4
DISCUSSION

Although a large proportion of combat-exposed veterans do not develop PTSD, it is important from a prevention and intervention standpoint to identify the psychological and cognitive variables that are associated with an increased risk of developing PTSD. The current study sheds light on several factors that influence the development of PTSD after deployment to war, specifically pre-morbid intellectual ability. Results of this study indicate a strong negative relationship between veterans' pre-deployment intellectual functioning and their post-deployment emotional functioning such that those veterans with lower intellectual functioning reported higher levels of post-deployment PTSD. This relationship remained after controlling for several salient individual factors, and appeared to be minimally affected by the experience of combat incurred mTBI. While mTBI cannot be ruled out as a factor influencing the development of PTSD, the current study suggests that cognitive functioning at the time of deployment has a strong influence on the development of emotional and cognitive functioning in the context of mTBI. These findings are consistent with the Cognitive Reserve hypothesis, which has been demonstrated in past studies by which intelligence had a strong negative relationship to emotional (Brewin et al., 2000; Gale et al., 2008; Gil et al., 1990; Gilbertson et al., 2001; Kremen et al., 2007; Macklin et al., 1998; McNally & Shin, 1995; Pitman et al., 1991; Vasterling et al., 1997; Vasterling et al., 2002; Wright et al., 2012) and cognitive functioning (Haut et al., 2007; Kesler et al., 2003). This relationship between intelligence and emotional functioning after war points to the need for the clarification of the modifiable components of intellectual functioning that are involved with protection against psychological dysfunction post-trauma.

One of the possible modifiable components of intellectual ability after trauma is Executive Functioning (EF; Cicerone, Levin, Malec, Stuss, & Whyte, 2006), which refers broadly to the functions associated with the frontal lobe systems of the brain. These functions include self-monitoring and awareness, initiation and sustained attention, inhibition, cognitive flexibility, and problem solving (Stuss & Alexander, 2000). Many of these functions can be adversely affected by both mTBI and PTSD, and are therefore a viable target for intervention efforts. The results of the current study suggest that individuals with AFQT scores above the mean for the sample had higher post-combat EF performance than those with AFQT scores below the mean of the sample. However, this finding may indicate that EF is simply a product of intellectual ability and general brain function itself, as further analysis determined that EF did not explain additional variance in PTSD symptoms above and beyond that of the pre-deployment intelligence estimate (AFQT).

While EF performance was not associated with PTSD beyond its relationship with general intelligence, it is possible that veterans who have a history of mTBI experience a decrease in general intellectual functioning post-deployment. To test this hypothesis we created an IQ change score, which was simply the difference in standardized z-scores between pre and post-deployment IQ estimates. This allowed us to determine which veterans had a reduction in performance on the IQ estimates from pre-to-post-deployment. Statistical analysis determined that there was a significant relationship between IQ change and severity of PTSD such that those veterans who had decreased intellectual functioning (NART) compared to the pre-combat AFQT reported significantly higher symptoms of PTSD. These results suggest the possibility that certain individuals possess cognitive attributes which allow them to better withstand trauma than others. Thus, the Cognitive Reserve hypothesis holds true in this veteran population, and higher intelligence prior to exposure to combat appears to be associated with better cognitive and emotional functioning post-combat.

Limitations, considerations, and future directions: Previous comparisons of the PCL-M and the BDI–II in their ability to identify PTSD suggest that both instruments may be tapping generalized distress rather than specific aspects of the disorder (Arbisi et al., 2012). Some authors note that reported depressive and PTSD symptoms often overlap in military populations in the acute re-adjustment period after deployment (Arbisi et al., 2012; Tsai, Pietrzak, Southwick, & Harpaz-Rotem, 2011). We believe that in this study we were able to distinguish reported PTSD symptoms from reported depressive symptoms due to the fact that our participants were seen in a time period, on average, beyond the acute post-deployment period than participants in these previous studies (M = 55.2 months).

In previous research (Grieger et al., 2006; Karney et al., 2008; Schell & Marshall, 2008) as well as in the current study, depressive symptom reporting was highly correlated with PTSD symptom reporting. In this study, the association between change in intellectual functioning from pre-to-post-combat and PTSD was examined. It was found that post-combat PTSD was significantly related to a pre-to-post-combat reduction in measured intellectual functioning. This general relationship was found when utilizing a word-list estimate of IQ (NART) as the post-combat outcome measure. Additionally, accounting for age, Time Since Injury, depressive symptoms and a proxy of combat exposure (LOC) reduced the unexplained variance in PTSD symptom reporting, resulting in a significant negative association between PTSD and measured intelligence change. A significant proportion of the lowered performance on neuropsychological testing measured in the current study can be attributed to the presence of increased levels of prolonged post-combat PTSD. In a similar investigation, Macklin and colleagues found that after controlling for combat exposure, no significant association existed between intelligence change and PTSD (Macklin et al., 1998). It is possible that this 1998 study failed to find a significant association between pre to post-deployment intelligence change and PTSD as a result of a failure to account for concurrent depressive symptoms in participants with PTSD. Alternatively, it is also possible that the self-report measure of PTSD employed in the present study had reduced diagnostic accuracy compared to the Clinician Administered PTSD Scale (CAPS) used in the Macklin study.

Some authors have found that factors such as social support and psychological resilience protect against the development of PTSD in OEF/OIF veterans (Pietrzak, Johnson, Goldstein, Malley, & Southwick, 2009). It is possible that including these factors in the prediction model would have mitigated the ability of the AFQT to predict PTSD symptom reporting. However, due to the fact that cognitive reserve and intelligence tend to be higher in those with home environments with strong familial bonds and social support, it is possible that the pre-deployment AFQT accounts for much of the same variance that psychological resilience accounted for in the 2009 Pietrzak study.

Individuals of higher intelligence may possess certain strengths which allow them to earn higher military rank or obtain a more desirable MOS during their time in service.

As such, it is possible that military rank and MOS are factors which can affect the results of research in this field. Because of the limited sample size of this study, military rank and MOS were not examined as possible influencing factors for or against the development of cognitive or emotional dysfunction and may be a limiting factor to the current findings. Preliminary investigation suggested that rank and MOS may be associated with combat exposure (LOC), which in turn may affect the development of cognitive and emotional dysfunction post-deployment. Future studies in this area of research should more directly evaluate the possibility that these factors are associated with post-deployment cognitive and emotional outcomes.

A final implication of the current results is that, if pre-deployment intelligence is a risk factor for development of PTSD, it may serve as a basis for targeting particular troops for pre-deployment preventative interventions designed to build resistance, increase psychological preparedness for war, and provide stress inoculation with the goal of reducing or preventing the development of combat-related PTSD in this population. The viability of such a preventative approach has not been investigated but would be a fruitful avenue for future research.

LIST OF REFERENCES

Ambrosini, P. J., Metz, C., Bianchi, M. D., & Rabinovich, H. (1991). Concurrent validity and psychometric properties of the Beck Depression Inventory in outpatient adolescents. *Journal of the American Academy of Child & Adolescent Psychiatry, 30*(1), 51-57. doi: 10.1097/00004583-199101000-00008

American Psychiatric Association. (2000). *Diagnostic and Statistical Manual of Mental Disorders* (Fourth, Text-Revision ed.). Washington, DC.: American Psychiatric Press.

Andrykowski, M. A., Cordova, M. J., Studts, J. L., & Miller, T. W. (1998). Posttraumatic stress disorder after treatment for breast cancer: Prevalence of diagnosis and use of the PTSD Checklist—Civilian Version (PCL—C) as a screening instrument. *J Consult Clin Psychol, 66*(3), 586-590. doi: 10.1037/0022-006x.66.3.586

Arbisi, P. A., Kaler, M. E., Kehle-Forbes, S. M., Erbes, C. R., Polusny, M. A., & Thuras, P. (2012). The Predictive Validity of the PTSD Checklist in a Nonclinical Sample of Combat-Exposed National Guard Troops. *Psychological Assessment*, 1034-1040. doi: 10.1037/a0028014

Arbuthnott, K., & Frank, J. (2000). Trail Making Test, Part B as a measure of executive control: Validation using a set-switching paradigm. *Journal of Clinical and Experimental Neuropsychology, 22*(4), 518-528. doi: 10.1076/1380-3395(200008)22:4;1-0;ft518

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Manual for the Beck Depression Inventory-II*. San Antonio, TX; Boston, MA: Psychological Corporation; Harcourt Brace.

Benton, A. L. (1967). Problems of Test Construction in the Field of Aphasia. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior, 3*(1), 32-58.

Blessed, G., Tomlinson, B. E., & Roth, M. (1968). The association between quantitative measures of dementia and of senile change in the cerebral grey matter of elderly subjects. *The British Journal of Psychiatry, 114*(512), 797-811. doi: 10.1192/bjp.114.512.797

Bliese, P. D., Wright, K. M., Adler, A. B., Cabrera, O., Castro, C. A., & Hoge, C. W. (2008). Validating the Primary Care Posttraumatic Stress Disorder Screen and the Posttraumatic Stress Disorder Checklist with soldiers returning from combat. *Journal of Consulting and Clinical Psychology, 76*(2), 272-281. doi: 10.1037/0022-006x.76.2.272

Brannick, M. T. (1990). Testing: Theoretical and Applied Perspectives. *Personnel Psychology, 43*(2), 432-435.

Brenner, L. A., Ivins, B. J., Schwab, K., Warden, D., Nelson, L. A., Jaffee, M., & Terrio, H. (2010). Traumatic Brain Injury, Posttraumatic Stress Disorder, and Postconcussive Symptom Reporting Among Troops Returning From Iraq. *The Journal of Head Trauma Rehabilitation, 25*(5), 307-312 310.1097/HTR.1090b1013e3181cada1003.

Brewin, C. R. (2005). Systematic Review of Screening Instruments for Adults at Risk of PTSD. *J Trauma Stress, 18*(1), 53-62. doi: 10.1002/jts.20007

Brewin, C. R., Andrews, B., & Valentine, J. D. (2000). Meta-analysis of risk factors for posttraumatic stress disorder in trauma-exposed adults. *J Consult Clin Psychol, 68*(5), 748-766. doi: 10.1037/0022-006x.68.5.748

Brooks, J., Fos, L. A., Greve, K. W., & Hammond, J. S. (1999). Assessment of Executive Function in Patients with Mild Traumatic Brain Injury. *The Journal of Trauma and Acute Care Surgery, 46*(1), 159-163.

Carlson, K. F., Nelson, D., Orazem, R. J., Nugent, S., Cifu, D. X., & Sayer, N. A. (2010). Psychiatric diagnoses among Iraq and Afghanistan war veterans screened for deployment-related traumatic brain injury. *Journal of Traumatic Stress, 23*(1), 17-24. doi: 10.1002/jts.20483

Charuvastra, A., & Cloitre, M. (2008). Social bonds and posttraumatic stress disorder. *Annual Review of Psychology, 59*, 301-328. doi: 10.1146/annurev.psych.58.110405.085650

Cicerone, K., Levin, H., Malec, J., Stuss, D., & Whyte, J. (2006). Cognitive Rehabilitation Interventions for Executive Function: Moving from Bench to Bedside in Patients with Traumatic Brain Injury. *Journal of Cognitive Neuroscience, 18*(7), 1212-1222. doi: 10.1162/jocn.2006.18.7.1212

Crawford, J. R., Parker, D. M., Stewart, L. E., & Besson, J. A. (1989). Prediction of WAIS IQ with the National Adult Reading Test: Cross-validation and extension. *British Journal of Clinical Psychology, 28*(3), 267-273.

Dolan, S., Martindale, S., Robinson, J., Kimbrel, N., Meyer, E., Kruse, M., . . . Gulliver, S. (2012). Neuropsychological Sequelae of PTSD and TBI Following War Deployment among OEF/OIF Veterans. *Neuropsychology Review, 22*(1), 21-34. doi: 10.1007/s11065-012-9190-5

Fay, T. B., Yeates, K. O., Taylor, H. G., Bangert, B., Dietrich, A., Nuss, K., . . . Wright, M. (2010). Cognitive reserve as a moderator of postconcussive symptoms in children with complicated and uncomplicated mild traumatic brain injury. *Journal of the International Neuropsychological Society, 16*(1), 94-105. doi: 10.1017/s1355617709991007

Feeny, N. C., & Foa, E. B. (2005). Cognitive Vulnerability to PTSD. In L. Alloy & J. Riskind (Eds.), *Cognitive Vulnerability to Emotional Disorders* (pp. 285-301). Mahwah, United States: Lawrence Erlbaum Associates Inc.

Gale, C. R., Deary, I. J., Boyle, S. H., Barefoot, J., Mortensen, L. H., & Batty, G. D. (2008). Cognitive ability in early adulthood and risk of 5 specific psychiatric disorders in middle age: The Vietnam Experience Study. *Archives of General Psychiatry, 65*(12), 1410-1418. doi: 10.1001/archpsyc.65.12.1410

Gil, T., Calev, A., Greenberg, D., Kugelmass, S., & et al. (1990). Cognitive functioning in Post-Traumatic Stress Disorder. *J Trauma Stress, 3*(1), 29-45. doi: 10.1002/jts.2490030104

Gilbertson, M. W., Gurvits, T. V., Lasko, N. B., Orr, S. P., & Pitman, R. K. (2001). Multivariate assessment of explicit memory function in combat veterans with posttraumatic stress disorder. *J Trauma Stress, 14*(2), 413-432. doi: 10.1023/a:1011181305501

Grieger, T. A., Cozza, S. J., Ursano, R. J., Hoge, C., Martinez, P. E., Engel, C. C., & Wain, H. J. (2006). Posttraumatic stress disorder and depression in battle-injured soldiers. *The American Journal of Psychiatry, 163*(10), 1777-1783. doi: 10.1176/appi.ajp.163.10.1777

Haut, M. W., Moran, M. T., Lancaster, M. A., Kuwabara, H., Parsons, M. W., & Puce, A. (2007). White Matter Correlates of Cognitive Capacity Studied With Diffusion Tensor Imaging: Implications for Cognitive Reserve. *Brain Imaging and Behavior, 1*(3-4), 83-92. doi: 10.1007/s11682-007-9008-x

Helmstaedter, C., & Kockelmann, E. (2006). Cognitive Outcomes in Patients with Chronic Temporal Lobe Epilepsy. *Epilepsia, 47*, 96-98. doi: 10.1111/j.1528-1167.2006.00702.x

Herrnstein, R. J., & Murray, C. A. (1994). *The bell curve: Intelligence and class structure in American life*. New York, NY, US: Free Press.

Hobfoll, S. E. (1989). Conservation of resources: A new attempt at conceptualizing stress. *American Psychologist, 44*(3), 513-524. doi: 10.1037/0003-066x.44.3.513

Hoge, C. W., Castro, C. A., Messer, S. C., McGurk, D., Cotting, D. I., & Koffman, R. L. (2004). Combat Duty in Iraq and Afghanistan, Mental Health Problems, and Barriers to Care. *The New England Journal of Medicine, 351*(1), 13-22. doi: 10.1056/NEJMoa040603

Karney, B. R., Ramchand, R., Osilla, K. C., Caldarone, L. B., & Burns, R. M. (2008). Predicting the Immediate and Long-Term Consequences of Post-Traumatic Stress Disorder, Depression, and Traumatic Brain Injury in Veterans of Operation Enduring Freedom and Operation Iraqi Freedom. In T. Tanielian & L. H. Jaycox (Eds.), Invisible Wounds of War: Psychological and Cognitive Injuries, Their Consequences, and Services to Assist Recovery. (pp. 119-153). Santa Monica, CA: RAND Corporation. Retrieved from http://www.rand.org/pubs/monographs/MG720.

Katzman, R. (1993). Education and the prevalence of dementia and Alzheimer's disease. *Neurology, 43*(1), 13-20.

Kennedy, C. H., Kupke, T., & Smith, R. (2000). A neuropsychological investigation of the Armed Services Vocational Aptitude Battery (ASVAB). *Archives of Clinical Neuropsychology, 15*(8), 696-697.

Kesler, S. R., Adams, H. F., Blasey, C. M., & Bigler, E. D. (2003). Premorbid Intellectual Functioning, Education, and Brain Size in Traumatic Brain Injury: An Investigation of the Cognitive Reserve Hypothesis. *Applied Neuropsychology, 10*(3), 153-162. doi: 10.1207/s15324826an1003_04

Kessler, R. C., Sonnega, A., Bromet, E., Hughes, M., & et al. (1995). Posttraumatic stress disorder in the National Comorbidity Survey. *Archives of General Psychiatry, 52*(12), 1048-1060. doi: 10.1001/archpsyc.1995.03950240066012

King, D. W., King, L. A., & Foy, D. W. (1996). Prewar factors in combat-related posttraumatic stress disorder: Structural equation modeling with a national sample of female and male Vietnam veterans. *J Consult Clin Psychol, 64*(3), 520-531. doi: 10.1037/0022-006x.64.3.520

Kremen, W. S., Koenen, K. C., Boake, C., Purcell, S., Eisen, S. A., Franz, C. E., . . . Lyons, M. J. (2007). Pretrauma cognitive ability and risk for posttraumatic stress disorder. *Archives of General Psychiatry, 64*(3), 361-368. doi: 10.1001/archpsyc.64.3.361

Lezak, M. D., Howieson, D. B., Loring, D. W., Hannay, H. J., & Fischer, J. S. (2004). *Neuropsychological assessment (4th ed.)*. New York, NY, US: Oxford University Press.

Macklin, M. L., Metzger, L. J., Litz, B. T., McNally, R. J., Lasko, N. B., Orr, S. P., & Pitman, R. K. (1998). Lower precombat intelligence is a risk factor for posttraumatic stress disorder. *Journal of Consulting and Clinical Psychology, 66*(2), 323-326. doi: 10.1037/0022-006x.66.2.323

Manne, S. L., Du Hamel, K., Gallelli, K., Sorgen, K., & Redd, W. H. (1998). Posttraumatic stress disorder among mothers of pediatric cancer survivors: Diagnosis, comorbidity, and utility of the PTSD Checklist as a screening instrument. *Journal of Pediatric Psychology, 23*(6), 357-366.

Marx, B. P., Brailey, K., Proctor, S. P., MacDonald, H. Z., Graefe, A. C., Amoroso, P., . . . Vasterling, J. J. (2009). Association of time since deployment, combat intensity, and posttraumatic stress symptoms with neuropsychological outcomes following Iraq war deployment. *Archives of General Psychiatry, 66*(9), 996-1004. doi: 10.1001/archgenpsychiatry.2009.109

Mathias, J. L., Bowden, S. C., & Barrett-Woodbridge, M. (2007). Accuracy of the Wechsler Test of Adult Reading (WTAR) and National Adult Reading Test (NART) when estimating IQ in a healthy Australian sample. *Australian Psychologist, 42*(1), 49-56. doi: 10.1080/00050060600827599

McNally, R. J., & Shin, L. M. (1995). Association of intelligence with severity of posttraumatic stress disorder symptoms in Vietnam combat veterans. *The American Journal of Psychiatry, 152*(6), 936-938.

Milliken, C. S., Auchterlonie, J. L., & Hoge, C. W. (2007). Longitudinal assessment of mental health problems among active and reserve component soldiers returning from the Iraq war. *JAMA: Journal of the American Medical Association, 298*(18), 2141-2148. doi: 10.1001/jama.298.18.2141

Moss, A. R., & Dowd, T. (1991). Does the NART hold after head injury? A case report. *British Journal of Clinical Psychology, 30*(2), 179-180. doi: 10.1111/j.2044-8260.1991.tb00934.x

Nelson, H. R. (1982). *National Adult Reading Test (NART): Test Manual*. Windsor: NFER-Nelson.

Orme, D. R., Brehm, W., & Ree, M. J. (2001). Armed forces qualification test as a measure of premorbid intelligence. *Military Psychology, 13*(4), 187-197. doi: Doi 10.1207/S15327876mp1304_1

Periáñez, J. A., Ríos-Lago, M., Rodríguez-Sánchez, J. M., Adrover-Roig, D., Sánchez-Cubillo, I., Crespo-Facorro, B., . . . Barceló, F. (2007). Trail Making Test in traumatic brain injury, schizophrenia, and normal ageing: Sample comparisons and normative data. *Archives of Clinical Neuropsychology, 22*(4), 433-447. doi: 10.1016/j.acn.2007.01.022

Pietrzak, R. H., Johnson, D. C., Goldstein, M. B., Malley, J. C., & Southwick, S. M. (2009). Psychological resilience and postdeployment social support protect against traumatic stress and depressive symptoms in soldiers returning from Operations Enduring Freedom and Iraqi Freedom. [Research Support, Non-U.S. Gov't]. *Depress Anxiety, 26*(8), 745-751. doi: 10.1002/da.20558

Pitman, R. K., Orr, S. P., Lowenhagen, M. J., Macklin, M. L., & Altman, B. (1991). Pre-Vietnam contents of posttraumatic stress disorder veterans' service medical and personnel records. *Comprehensive Psychiatry, 32*(5), 416-422.

Poppen, B., & Southwell, G. (2003). *ASVAB scores as predictors of premorbid general level of cognitive functioning.* Paper presented at the 6th Annual Force Health Protection Conference/Behavioral Science Short Course. U.S. Army Center for Health Promotion and Preventive Medicine, Albuquerque, NM; Aberdeen Proving Ground, MD.

Pratt, E. M., Brief, D. J., & Keane, T. M. (2006). Recent Advances in Psychological Assessment of Adults with Posttraumatic Stress Disorder. In V. M. R. Follette, Josef I. (Ed.), *Cognitive-behavioral therapies for trauma* (2nd ed., pp. 34-61). New York, NY, US: Guilford Press.

Ramchand, R., Karney, B. R., Osilla, K. C., Burns, R. M., & Caldarone, L. B. (2008). Prevalence of PTSD, Depression, and TBI Among Returning Servicemembers. In T. Tanielian & L. H. Jaycox (Eds.), Invisible Wounds of War: Psychological and Cognitive Injuries, Their Consequences, and Services to Assist Recovery. (pp. 35-85). Santa Monica,CA: RAND Corporation.

Raskin, S. A., Mateer, C. A., & Tweeten, R. (1998). Neuropsychological assessment of individuals with mild traumatic brain injury. *Clinical Neuropsychologist, 12*(1), 21-30. doi: 10.1076/clin.12.1.21.1724

Raskin, S. A., & Rearick, E. (1996). Verbal fluency in individuals with mild traumatic brain injury. *Neuropsychology, 10*(3), 416-422. doi: 10.1037/0894-4105.10.3.416

Reitan, R. M. (1958). Validity of the Trail Making Test as an indicator of organic brain damage. *Perceptual and Motor Skills, 8*, 271-276. doi: 10.2466/pms.8.7.271-276

Renshaw, K. D. (2011). An integrated model of risk and protective factors for post-deployment PTSD symptoms in OEF/OIF era combat veterans. *Journal of Affective Disorders, 128*(3), 321-326.

Salthouse, T. A., Atkinson, T. M., & Berish, D. E. (2003). Executive Functioning as a Potential Mediator of Age-Related Cognitive Decline in Normal Adults. *Journal of Experimental Psychology: General, 132*(4), 566-594. doi: 10.1037/0096-3445.132.4.566

Satz, P. (1993). Brain reserve capacity on symptom onset after brain injury: A formulation and review of evidence for threshold theory. *Neuropsychology, 7*(3), 273-295. doi: 10.1037/0894-4105.7.3.273

Scarmeas, N., Zarahn, E., Anderson, K. E., Hilton, J., Flynn, J., Van Heertum, R. L., . . . Stern, Y. (2003). Cognitive reserve modulates functional brain responses during memory tasks: a PET study in healthy young and elderly subjects. *NeuroImage, 19*(3), 1215-1227.

Schell, T. L., & Marshall, G. N. (2008). Survey of Individuals Previously Deployed for OEF/OIF. In T. Tanielian & L. H. Jaycox (Eds.), Invisible Wounds of War: Psychological and Cognitive Injuries, Their Consequences, and Services to Assist Recovery (pp. 87-115). Santa Monica, CA: RAND Corporation.

Schneiderman, A. I., Braver, E. R., & Kang, H. K. (2008). Understanding sequelae of injury mechanisms and mild traumatic brain injury incurred during the conflicts in Iraq and Afghanistan: persistent postconcussive symptoms and posttraumatic stress disorder. [Research Support, U.S. Gov't, Non-P.H.S.]. *Am J Epidemiol, 167*(12), 1446-1452. doi: 10.1093/aje/kwn068

Seal, K. H., Bertenthal, D., Miner, C. R., Sen, S., & Marmar, C. (2007). Bringing the War Back Home: Mental Health Disorders Among 103 788 US Veterans Returning From Iraq and Afghanistan Seen at Department of Veterans Affairs Facilities. *Arch Intern Med, 2007*(167), 476-482.

Seifert, A. E., Polusny, M. A., & Murdoch, M. (2011). The association between childhood physical and sexual abuse and functioning and psychiatric symptoms in a sample of U.S. Army soldiers. *Military Medicine, 176*(2), 176-181.

Senathi-Raja, D., Ponsford, J., & Schonberger, M. (2010). The Association of Age and Time Postinjury With Long-Term Emotional Outcome Following Traumatic Brain Injury. *The Journal of Head Trauma Rehabilitation, 25*(5), 330-338 310.1097/HTR.1090b1013e3181ccc1893.

Sprinkle, S. D., Lurie, D., Insko, S. L., Atkinson, G., Jones, G. L., Logan, A. R., & Bissada, N. N. (2002). Criterion validity, severity cut scores, and test-retest reliability of the Beck Depression Inventory-II in a university counseling center sample. *Journal of Counseling Psychology, 49*(3), 381-385. doi: 10.1037/0022-0167.49.3.381

Stern, Y. (2002). What is cognitive reserve? Theory and research application of the reserve concept. *Journal of the International Neuropsychological Society, 8*(3), 448-460. doi: 10.1017/s1355617702813248

Storch, E. A., Roberti, J. W., & Roth, D. A. (2004). Factor Structure, Concurrent Validity, and Internal Consistency of the Beck Depression Inventory-Second Edition in a Sample of College Students. *Depress Anxiety, 19*(3), 187-189. doi: 10.1002/da.20002

Stuss, D. T., & Alexander, M. P. (2000). Executive functions and the frontal lobes: A conceptual view. *Psychological Research/Psychologische Forschung, 63*(3-4), 289-298. doi: 10.1007/s004269900007

Stuss, D. T., Bisschop, S. M., Alexander, M. P., Levine, B., Katz, D., & Izukawa, D. (2001). The trail making test: A study in focal lesion patients. *Psychol Assess, 13*(2), 230-239. doi: 10.1037/1040-3590.13.2.230

Tanielian, T., Jaycox, L. H., Schell, T. L., Marshall, G. N., & Vaiana, M. E. (2008). Treating the Invisible Wounds of War: Conclusions and Recommendations. In T. Tanielian & L. H. Jaycox (Eds.), Invisible Wounds of War: Psychological and Cognitive Injuries, Their Consequences, and Services to Assist Recovery (pp. 431-453). Santa Monica, CA: RAND Corporation.

Tsai, J., Pietrzak, R. H., Southwick, S. M., & Harpaz-Rotem, I. (2011). Examining the dimensionality of combat-related posttraumatic stress and depressive symptoms in treatment-seeking OEF/OIF/OND veterans. *J Affect Disord, 135*(1-3), 310-314. doi: 10.1016/j.jad.2011.06.057

VA/DoD. (2009). *Management of Concussion/Mild Traumatic Brain Injury (mTBI)*.

Vasterling, J. J., Brailey, K., Constans, J. I., Borges, A., & et al. (1997). Assessment of intellectual resources in Gulf War veterans: Relationship to PTSD. *Assessment, 4*(1), 51-59. doi: 10.1080/0969594970040104

Vasterling, J. J., Duke, L. M., Brailey, K., Constans, J. I., Allain, A. N., & Sutker, P. B. (2002). Attention, learning, and memory performances and intellectual resources in Vietnam veterans: PTSD and no disorder comparisons. *Neuropsychology, 16*(1), 5-14. doi: 10.1037/0894-4105.16.1.5

Weathers, F. W., & Ford, J. (1996). Psychometric review of the PTSD Checklist. In B. H. Stamm (Ed.), *Measurement of stress, trauma, and adaptation* (pp. 250-251). Lutherville, MD: Sidran Press.

Weathers, F. W., Huska, J., & Keane, T. (1991). *The PTSD Checklist-Military version (PCL-M)*. Paper presented at the National Center for Posttraumatic Stress Disorder, Boston, MA, US.

Werheid, K., Hoppe, C., Thöne, A., Müller, U., Müngersdorf, M., & von Cramon, D. Y. (2002). The Adaptive Digit Ordering Test. Clinical application, reliability, and validity of a verbal working memory test. *Archives of Clinical Neuropsychology, 17*(6), 547-565. doi: 10.1016/s0887-6177(01)00134-2

Willshire, D., Kinsella, G., & Prior, M. R. (1991). Estimating WAIS—R IQ from the National Adult Reading Test: A cross-validation. *Journal of Clinical and Experimental Neuropsychology, 13*(2), 204-216. doi: 10.1080/01688639108401038

Wright, K. M., Cabrera, O. A., Eckford, R. D., Adler, A. B., & Bliese, P. D. (2012). The impact of predeployment functional impairment on mental health after combat. *Psychological Trauma: Theory, Research, Practice, and Policy, 4*(3), 260-269. doi: 10.1037/a0024373

BIOGRAPHICAL SKETCH

Joseph Gullett received his Bachelor of Science degree in psychology (Cum Laude) from the University of Florida in 2008. As an undergraduate, he worked as a research assistant under the guidance of Dr. Michael Marsiske in the Department of Clinical and Health Psychology. He maintained a relationship with the CHP faculty after earning his degree when he began endeavors with clinical populations as a psychometrician at the University of Florida Psychology Clinic. During the time since his undergraduate study, Joseph has presented several independent research projects at international conferences, and has also written a first-author publication on the clinical utility of a modified neuropsychological test for use in Parkinson's disease patients. A short time later, his research focus evolved into the study of Diffusion Tensor Imaging of brain injured veterans at the Malcom Randall VA under the mentorship of neurologist David B. FitzGerald, MD. It was during the development and implementation of this research study while also continuing clinical work at the Psychology Clinic that Mr. Gullett received an offer to begin work as a graduate student in the Department of Clinical and Health Psychology under the mentorship of Dr. Russell Bauer.