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The Contributions of Self-reported Injury Characteristics and Psychiatric Symptoms to Cognitive Functioning in OEF/OIF Veterans with Mild Traumatic Brain Injury

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Abstract

Mild traumatic brain injury (mTBI) affects a significant number of combat veterans returning from Operation Enduring Freedom/Operation Iraqi Freedom (OEF/OIF). Although resolution of mTBI symptoms is expected over time, some individuals continue to report lingering cognitive difficulties. This study examined the contributions of self-reported mTBI injury characteristics (e.g., loss of consciousness, post-traumatic amnesia) and psychiatric symptoms to both subjective and objective cognitive functioning in a sample of 167 OEF/OIF veterans seen in a TBI clinic. Injury characteristics were not associated with performance on neuropsychological tests but were variably related to subjective ratings of cognitive functioning. Psychiatric symptoms were highly prevalent and fully mediated most of the relationships between injury characteristics and cognitive ratings. This indicates that mTBI characteristics such as longer time since injury and loss of consciousness or post-traumatic amnesia can lead to increased perceived cognitive deficits despite having no objective effects on cognitive performance. Psychiatric symptoms were associated with both cognitive ratings and neuropsychological performance, illustrating the important role that psychiatric treatment can potentially play in optimizing functioning. Finally, subjective cognitive ratings were not predictive of neuropsychological performance once psychiatric functioning was statistically controlled, suggesting that neuropsychological assessment provides valuable information that cannot be gleaned from self-report alone. (*JINS*, 2012, *18*, 576–584)

Keywords: Neuropsychology, Head injuries, Anxiety, Depression, PTSD, Military

INTRODUCTION

Mild traumatic brain injury (mTBI) is considered the "signature injury" of Operation Enduring Freedom/Operation Iraqi Freedom (OEF/OIF). According to the Defense and Veterans Brian Injury Center (2011), there have been over 140,000 incident diagnoses of mTBI amongst service members since 2002. mTBI is defined by the American Congress of Rehabilitation Medicine as a head trauma that produces either (1) a loss of consciousness (LOC) of 30 min or less, (2) posttraumatic amnesia (PTA) as indicated by any loss of memory immediately before or after the injury lasting less than 24 h, (3) any alteration in mental state at the time of the injury (i.e., disorientation), or (4) focal neurological deficit (Kay et al., 1993). Although LOC and PTA are the most common characteristics associated with mTBI, disorientation can also qualify for a diagnosis. Disorientation can occur for a variety of non-injury related reasons (e.g., acute stress, non-TBI injury) and, therefore, the use of this criteria alone to diagnose mTBI has been questioned (e.g., Hoge, Goldberg, & Castro, 2009), as it may reflect a less severe injury or a misdiagnosis. Thus, mTBI injuries involving only a period of disorientation may be less severe or even qualitatively distinct from those injuries involving LOC and/or PTA. Further complicating diagnosis, PTA and LOC can be easily confused, particularly if there are no witnesses to provide objective clarification, and it is often challenging for both patients and clinicians to accurately distinguish between the two (Ruff et al., 2009).

mTBI can lead to a variety of acute physical, emotional, and cognitive symptoms that are expected to improve over

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time. For example, changes in cognitive functioning are common immediately following mTBI, with some individuals experiencing problems in the days and weeks following head injuries (Iverson, 2005; Rohling et al., 2011). These deficits are typically transient, with the expectation for full resolution of symptoms within weeks to months post-injury (Belanger, Curtiss, Demery, Lebowitz, & Vanderploeg, 2005; Binder, Rohling, & Larrabee, 1997; Carroll et al., 2004; Schretlen & Shapiro, 2003; Tanielian & Jaycox, 2008).

Although the majority of individuals experience full symptom resolution, some continue to report lingering cognitive difficulties. These cognitive complaints are often part of a constellation of emotional, cognitive, and behavioral post-concussive symptoms that can include headache, dizziness, fatigue, sleep problems, and irritability. These symptoms are non-specific to mTBI and are likely related, at least in part, to comorbid factors such as psychiatric symptoms. Situations in which mTBI occur are often highly emotional and stressful and it is not surprising that psychiatric diagnoses are highly comorbid with mTBI. Carlson and colleagues (2010) found that 80% of veterans screening positive for TBI also carried at least one psychiatric diagnosis. Veterans with positive TBI screens were three times more likely to have post-traumatic stress disorder (PTSD) and twice as likely to have depression and substance use disorders than veterans without TBI.

Given the high comorbidity between mTBI and psychiatric disorders, it is likely that psychiatric symptoms contribute to, perpetuate, and/or underlie persisting cognitive complaints. Disorders such as depression and PTSD can affect neuropsychological performance (Austin, Mitchell, & Goodwin, 2001; Golier & Yehuda, 2002; Iverson, Zasler, & Lange, 2006; Langenecker, Lee, & Bieliauskas, 2009; Vasterling et al., 2002) and also negatively impact an individual's subjective perception of his or her cognitive abilities. For instance, depression has been associated with cognitive complaints in TBI as well as other medical conditions (Chamelian & Feinstein, 2006; McCracken & Iverson, 2001; Wearden & Appleby, 1996). More generally, depressed individuals without head injuries report more post-concussive symptoms than individuals with head injuries (Fox, Lees-Haley, Earnest, & Dolezal-Wood 1995; Guskiewicz et al., 2003; Iverson et al., 2006; Lees-Haley, Fox, & Courtney, 2001; McLean et al., 2009).

Several studies have examined relationships amongst mTBI, self-reported post-concussive symptoms, and psychiatric functioning in OEF/OIF veterans with the consistent finding that psychiatric symptoms significantly contribute to post-concussive symptoms in mTBI. Schneiderman, Braver, and Kang (2008) showed that veterans with mTBI and PTSD were four times more likely to endorse post-concussive symptoms than veterans with mTBI alone. Belanger, Uomoto, and Vanderploeg (2009) found that soldiers with mTBI endorsed more post-concussive symptoms than soldiers with moderate-to-severe TBI, although this difference was no longer significant once PTSD was controlled.

Other studies have more specifically examined psychiatric contributions to self-reported cognitive symptoms. Polusny and colleagues (2011) demonstrated that although mTBI was associated with higher rates of self-reported memory problems in veterans, this relationship was no longer significant after adjusting for PTSD. A widely cited study by Hoge and colleagues (2008) examined whether injury characteristics predicted post-concussive symptoms in soldiers with mTBI compared to soldiers with non-TBI injuries. They found that soldiers with mTBI reporting LOC and soldiers with mTBI reporting altered mental status reported more problems with attention and memory than soldiers with a non-TBI injury. However, this relationship was no longer significant once depression and PTSD were statistically controlled.

These findings suggest that psychiatric factors significantly contribute to apparent relationships between mTBI characteristics and perceived cognitive functioning among OEF/OIF veterans. Less is known, however, about the effects of injury characteristics and psychiatric symptoms on objective cognitive functioning. We previously reported that self-reports of cognitive abilities are not corroborated by objective neuropsychological performance in this population (Spencer, Drag, Walker, & Bieliauskas, 2010). Thus, findings from previous research examining subjective cognitive functioning (e.g., Hoge et al., 2008) may not necessarily generalize to objective cognitive performance. The purpose of this study was to examine the contributions of self-reported mTBI injury characteristics and psychiatric symptoms to both subjective and objective aspects of cognitive functioning in a sample of OEF/OIF veterans with mTBI seen for care in a VA TBI Clinic. This study is a retrospective, secondary analysis of data collected as part of standard clinical care in this clinic.

METHOD

Participants

Data were analyzed in compliance with human subjects regulations of the VA Ann Arbor Healthcare System. This study included data from 449 veterans seen consecutively in the TBI Clinic at the VA Ann Arbor Healthcare System. These veterans were referred to the TBI clinic by other VA clinicians or after screening positive for a possible head injury on a VA TBI screening tool that is given to all OEF/OIF veterans without a prior diagnosis of TBI during OEF/OIF seeking care at a VA medical facility (Government Accountability Office, 2008). This screen inquires about injuries sustained during the deployment, mental status following these injuries, and the presence of post-concussive symptoms both after the injury and over the past week. As part of standard clinical care, veterans seen in the TBI clinic receive a secondary evaluation, which includes a comprehensive evaluation of blast exposures and TBI events, a targeted review of systems, a physical examination by a physiatrist, a brief neuropsychological assessment and the Neurobehavioral Symptom Inventory (NSI; Cicerone & Kalmar, 1995). The NSI is a 22-item self-report checklist of post-concussive symptoms. Veterans' responses on the NSI were reviewed with a trained social worker or licensed psychologist. Information about injury characteristics was obtained by a trained physiatrist or social worker specializing in TBI. A structured interview following the VA Comprehensive TBI Evaluation template was used to collect injury data. The interview consisted of open-ended questions about possible injuries and more targeted follow-up questions as needed. Clinical judgment was used in any ambiguous situations or in the case of conflicting information. As required by the VA template, data on injury characteristic were recorded categorically (e.g., <1 min or 1–30 min for LOC and <30 min or 30 min to 24 h for disorientation and PTA).

Veterans were included in the study if their self-reported injury characteristics met American Congress of Rehabilitation Medicine criteria for mTBI as evidenced by either an episode of LOC of 30 min or less or a period of disorientation or altered mental status of 24 h or less. Exclusion criteria included evidence of insufficient effort on at least one of two effort measures, an estimated verbal IQ of 70 or below as measured by the Shipley Institute of Living Scale Vocabulary Subtest (Zachary, 2000), data collection as part of a compensation and pension evaluation, and incomplete data. A total of 282 participants were excluded due to the following, non-mutually exclusive reasons: 48 participants had injuries exceeding a mTBI, 65 were seen as part of a compensation and pension evaluation, 19 scored below the cutoff on Digit Span (DS; see below description of the neuropsychological assessment), 13 scored below the cutoff on the Rey-15, 212 participants had incomplete data, 59 did not meet minimum criteria for mTBI, and 80 scored below the cutoff on the Shipley Vocabulary. After these inclusion and exclusion criteria were applied, data from a total of 167 participants were included in the current study, four of whom were female. Participants ranged in age from 21 to 58 ($M = 29.47$; $SD = 7.28$) with years of formal education ranging from 7 to 20 years ($M = 12.89$; $SD = 1.63$). On average, participants were seen in the TBI clinic 41.93 months following their most recent injury ($SD = 34.06$), with a range of 1 to 228 months. Sixty-nine percent of participants had at least one service-connected condition in their electronic medical record (i.e., a disabling injury or disease that occurred while on active duty or were made worse by active military service). Twenty four participants (14.37%) were service-connected for TBI in particular. In the VA system, each service-connected condition is given a disability rating from 0 to 100 in increments of 10, with a score of 0 indicating no interference with functioning, 10 indicating mild or transient symptoms that decrease work efficiency or that can be controlled by continuous medication, 30 indicating an occasional decrease in work efficiency and intermittent periods of inability to perform occupational tasks, and 100 indicating total impairment. Individuals are eligible to receive disability compensation based on these ratings (Government Accountability Office, 2005). The average TBI disability rating in our sample was 26.25 (range, 10–70). A review of formal diagnoses in the problem list of participants' medical records indicated the following prevalence rates: 72% for PTSD, 54% for an affective disorder, 29% for anxiety, 14% for an adjustment disorder, 20% for a substance use disorder, 13% for pain disorder, and 31% for a sleep disorder.

MATERIALS AND PROCEDURES

Injury Characteristics

During the structured interview with a clinician, participants provided information about the number and duration of episodes for each of three TBI variables: LOC, PTA, and disorientation. Participants were divided into two groups: individuals endorsing only disorientation but not PTA or LOC (the Disorientation group; $N = 75$) and individuals endorsing PTA and/or LOC (the PTA/LOC group; $N = 92$).

Neuropsychological Assessment

Self-report ratings of cognitive functioning were obtained from responses on the NSI. Participants provided ratings of cognitive functioning across the domains of Concentration, Memory, Decision-Making, and Processing Speed. Ratings were given on a Likert scale from 0 to 4, with 0 indicating symptoms that are "rarely if ever present; not a problem at all" and 4 indicating very severe problems that are "almost always present" and lead to an inability to perform necessary tasks at work, school, or home. Ratings of 1, 2, and 3 are regarded as mild, moderate, and severe, respectively.

Participants also completed a 45-min neuropsychological assessment designed to assess aspects of attention and concentration, memory, executive functioning, and complex visual processing as well as psychiatric symptoms. Self-reported symptoms of anxiety and depression were collected using the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983). Symptoms of PTSD were measured using the PTSD Checklist-Military Version (PCL-M; Weathers, Litz, Huska, & Keane, 1993). Scores of 8 and above on the HADS and 50 and above on the PCL-M are indicative of significant psychiatric symptoms.

Neuropsychological variables of interest were: time to completion on parts A and B of the Trail Making Test (Strauss, Sherman, & Spreen, 2006); immediate and delayed Story Memory from the Repeatable Battery for the Assessment of Neuropsychological Status (Randolph, 1998); copy accuracy, time to copy, copy organization, and immediate recall from the Rey Complex Figure Test (RCFT; Meyers & Meyers, 1995); digits forward, digits backward, and digit sequencing from the Digit Span (DS) subtest of the Wechsler Adult Intelligence Scale-IV (Wechsler, 2008); and the Vocabulary subtest from the Shipley Institute of Living Scale. Raw scores were converted to *t* scores based on age-referenced norms with the exception of copy organization, copy accuracy, and time to copy from the RCFT as these indices are either associated with broad percentile ranges or do not have adequate normative data. Effort was assessed with the Rey 15-Item Memory Test (Rey, 1964) as well as the total DS age-corrected composite scaled score. Evidence of inconsistent effort was based on a scaled score of four or below on DS (Axelrod, Fichtenberg, Millis, & Wertheimer, 2006) or a raw score of 8 or below on the Rey 15-Item Memory Test.

To reduce the number of variables, neuropsychological variables were grouped a priori into conceptual categories based on task demands. Confirmatory principal components factor analyses with varimax rotation were conducted to confirm the groupings and create composite factor scores. Variables measuring frontal functioning were entered into a factor analysis: Trails A, Trails B, DS Forward, DS Backward, and DS Sequencing. The factor analysis yielded two separate factors, a Visual Attention factor with Trails A and B loading most strongly (loadings > 0.6) and a Verbal Attention factor with DS Forward, DS Backward, and DS Sequencing loading most strongly (loadings > 0.6). The memory subtests (Story Immediate, Story Delayed, and RCFT Recall were entered together into a factor analysis and loaded on one Memory factor (loadings > 0.6). The remaining RCFT variables (time to copy, copy organization, and copy accuracy) were entered together and all loaded on one Complex Visual Processing factor (loadings > 0.6). Factor scores for Visual Attention, Verbal Attention, Memory, and Complex Visual Processing were computed for each participant using the regression method and then converted into a *t* score for easier interpretation. Higher scores indicated better performance.

RESULTS

There were no significant differences between the Disorientation group and the LOC/PTA group for age, $F(1,165) = .27$, $p = .60$, education, $F(1,165) = .09$, $p = .76$, Vocabulary *t* scores, $F(1,165) = .00$, $p = .99$, or Time Since Injury, $F(1,165) = .01$, $p = .93$. Scores on the neuropsychological tests and psychiatric scales for the Disorientation and LOC/PTA groups are shown in Table 1.

Injury Characteristics

Seventy of the 167 participants (42%) reported at least one episode of LOC, with the majority of these participants (86%) endorsing a single episode ($M = 1.23$; $SD = 0.66$; range, 1–5). Thirty-nine of these participants (56%) endorsed LOC duration less than 1 min while 31 participants (44%) reported LOC duration between 1 and 29 min. Fifty participants (30%) endorsed PTA, with an average of 1.42 episodes ($SD = 0.86$; range 1–5). Seventy percent of these participants endorsed PTA duration between 1 and 29 min. A total of 164 participants (98%) endorsed disorientation with an average of 2.12 episodes ($SD = 1.31$; range = 1–5). Of these 164 participants, 105 (64%) reported disorientation duration lasting less than 30 min.

Psychiatric Symptoms

A total of 148 participants (89%) endorsed significant symptoms of anxiety on the HADS, 114 (68%) endorsed significant symptoms of depression on the HADS, and 99 (59%) endorsed significant symptoms of PTSD on the

Table 1. Neuropsychological and psychiatric scores and self-reported mTBI injury characteristics expressed as mean (standard deviation)

	Disorientation ($N = 75$)	PTA/LOC ($N = 92$)	Notes
Shipley Vocabulary	49.15 (7.50)	49.15 (6.20)	$M = 50$; $SD = 10$
DS Forward	8.39 (2.63)	8.64 (2.70)	$M = 10$; $SD = 3$
DS Backward	9.23 (2.54)	8.92 (2.18)	$M = 10$; $SD = 3$
DS Sequencing	9.30 (2.76)	9.41 (2.27)	$M = 10$; $SD = 3$
Verbal Attention	49.69 (10.91)	49.87 (9.69)	$M = 50$; $SD = 10$
Trails A	48.93 (10.83)	47.99 (11.04)	$M = 50$; $SD = 10$
Trails B	49.96 (8.35)	48.80 (8.65)	$M = 50$; $SD = 10$
Visual Attention	50.67 (9.61)	49.61 (10.36)	$M = 50$; $SD = 10$
Story Immediate	44.99 (10.19)	48.10 (10.36)	$M = 50$; $SD = 10$
Story Delayed	45.41 (10.49)	44.98 (10.71)	$M = 50$; $SD = 10$
RCFT Recall	44.43 (12.72)	44.50 (13.65)	$M = 50$; $SD = 10$
Memory Factor	49.22 (9.89)	49.61 (10.36)	$M = 50$; $SD = 10$
RCFT Copy (raw)	33.72 (2.64)	33.78 (2.38)	Raw, range 0–36
RCFT Organization	3.64 (1.74)	3.99 (1.81)	Raw, range 0–6
RCFT Time	170.51 (63.07)	166.17 (74.91)	Raw
Visual Organization	49.08 (9.98)	50.46 (10.12)	$M = 50$; $SD = 10$
PCL-M	50.61 (16.24)	56.74 (14.61)*	Cutoff: 50
HADS Anxiety	11.56 (4.06)	13.16 (3.92)*	Cutoff: 8
HADS Depression	7.95 (4.61)	10.34 (4.013)**	Cutoff: 8
NSI			
Concentration	2.08 (1.21)	2.71 (1.12)**	Range: 0–4
Memory	2.17 (1.16)	2.86 (1.18)**	Range: 0–4
Decision-Making	1.59 (1.365)	2.05 (1.36)*	Range: 0–4
Processing Speed	1.80 (1.32)	2.38 (1.29)*	Range: 0–4

DS = Digit Span, RCFT = Rey Complex Figure Test, PCL = PTSD Checklist, HADS = Hospital Anxiety and Depression Scale; NSI = Neurobehavioral Symptom Inventory.
*$p < .05$; ** $p < .001$.

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Table 2. Correlations among psychiatric variables and cognitive variables

	PTSD	Anxiety	Depression
Verbal Attention	−0.21*	−0.24**	−0.24*
Visual Attention	−0.20*	−0.12	−0.13
Complex Visual Processing	−0.18*	−0.12	−0.15
Memory	−0.34*	−0.29**	−0.25**
CR Concentration	0.59**	0.56**	0.55**
CR Memory	0.53**	0.49**	0.51**
CR Decision-Making	0.63**	0.52**	0.57**
CR Processing Speed	0.68**	0.58**	0.62**
PTSD	–	0.76*	0.76**
Anxiety	–	–	0.56**
Depression	–	–	–

CR = Cognitive ratings.
*$p < .05$, **$p < .001$.

PCL-M. Sixteen participants (10%) did not endorse significant psychiatric symptoms on any measure whereas 89 participants (53%) endorsed significant symptoms on all three measures. Psychiatric symptoms were correlated with cognitive ratings and the cognitive factor scores, as displayed in Table 2.

Given the high correlations amongst the psychiatric variables, a Psychiatric factor score was created using a principal components factor analysis. All three psychiatric variables loaded highly on this factor (loadings $> .8$), which was used in subsequent analyses as a covariate.

Injury Characteristics and Psychiatric Symptoms

Analyses of variance (ANOVAs) indicated significant differences between the Disorientation and PTA/LOC groups on the PCL-M, $F(1,165) = 6.40$, $p < .05$, the Anxiety scale on the HADS, $F(1,165) = 6.69$, $p < .05$, and the Depression scale on the HADS, $F(1,165) = 12.93$, $p < .001$. The PTA/LOC group endorsed more severe symptoms than the Disorientation group on each of all scales.

Injury Characteristics and Objective Cognitive Functioning

Time since injury was not significantly correlated with Verbal Attention ($r = .05$; $p = .51$), Visual Attention ($r = -.01$; $p = .89$), Memory ($r = .13$; $p = .10$) or Visual Processing ($r = .00$; $p = .91$). ANOVAs indicated no significant differences between the Disorientation and PTA/LOC groups for Verbal Attention $F(1,165) = .01$, $p = .91$, Visual Attention, $F(1,165) = .47$, $p = .50$, Memory, $F(1,165) = .54$, $p = .46$, or Visual Processing, $F(1,165) = .78$, $p = .38$.

Injury Characteristics and Subjective Cognitive Functioning

Time since injury was significantly correlated to self-reported problems with Decision-Making, $r = .21$, $p < .05$, and Processing Speed, $r = .15$, $p < .05$, with longer time since injury associated with greater self-rated cognitive impairment. When both time since injury and the Psychiatric Factor were entered as predictors in forced entry multiple regression analyses, time since injury was no longer associated with Processing Speed, $\beta = .07$, $p = .20$, but continued to be a significant predictor of Decision-Making, $\beta = .14$, $p < .05$.

ANOVAs indicated significant differences between the Disorientation and PTA/LOC groups for Concentration, $F(1,165), = 12.351$, $p < .001$, Memory $F(1,165), = 14.17$, $p < .001$, Decision-Making, $F(1,165), = 4.89$, $p < .05$, and Processing Speed, $F(1,165), = 8.15$, $p < .05$, with the PTA/LOC endorsing higher ratings on all four measures. When the Psychiatric Factor was entered into the analyses as a covariate, group differences remained significant only for Memory ratings, $F(1,164), = 5.92$, $p < .05$.

Service-Connection and Cognitive Functioning

Comparing differences in cognitive functioning between veterans with and without at least one service-connected condition ($N = 116$ and 51, respectively), an ANOVA indicated that the service-connected group had higher ratings of perceived difficulties in Concentration, $F(1,165) = 8.98$, $p < .05$, Memory, $F(1,165) = 14.03$, $p < .001$, Decision-Making, $F(1,165) = 6.19$, $p < .05$, Processing Speed, $F(1,165) = 8.08$, $p < .05$, but not in objective performance on Verbal Attention $F(1,165) = 0.66$, $p = .42$, Visual Attention, $F(1,165) = 1.92$, $p = .17$, Memory, $F(1,165) = 1.87$, $p = .17$, and Visual Processing, $F(1,165) = 0.33$, $p = .57$.

Subjective and Objective Cognitive Functioning

Using a sample of participants that overlapped with 41 of the participants in the current sample, Spencer and colleagues (2010) demonstrated that cognitive ratings were not accurate indicators of neuropsychological performance in mTBI. To replicate these findings in an independent sample, these associations were examined among a subset of 126 participants in the current study who had not been included in the previous study. Correlations between the cognitive ratings and cognitive factors were variable and are reported in Table 3. When the Psychiatric factor was entered along with the cognitive ratings as a predictor in forced entry multiple regression analyses, none of the cognitive ratings were a significant predictor of any of the cognitive factors, all β absolute values <0.31.

DISCUSSION

Self-reported injury characteristics were not associated with cognitive performance in a sample of OEF/OIF veterans with mTBI seen in a TBI clinic. Injury characteristics were associated with subjective ratings of cognitive functioning, although psychiatric symptoms accounted for most of these relationships. Psychiatric symptoms were highly prevalent in this sample and correlated with both neuropsychological performance and subjective cognitive ratings. Service-connection was associated with increased cognitive complaints but not objective cognitive performance. This study also

Table 3. Correlations between cognitive factors and cognitive ratings

	Cognitive ratings			
	Concentration	Memory	Decision-making	Processing speed
Verbal Attention	−.20*	−.12	−.11	−.21*
Visual Attention	−.04	−.14	−.06	−.12
Memory	−.27**	−.21*	−.17*	−.30**
Complex Visual Processing	−.04	−.08	−.17	−.12

Note: $N = 126$.

provided confirmation of previous findings (Spencer et al., 2010) that self-report of cognitive functioning is not an accurate indicator of objectively measured cognitive abilities.

Objective Cognitive Functioning

Self-reported mTBI injury characteristics were not associated with neuropsychological test performance. This suggests that more severe mTBI injuries were not associated with increased objective cognitive difficulties. Although on average, participants performed well within normal limits on the cognitive tasks, there was variability in performance across individuals, as is to be expected in large samples. When individuals demonstrate low performance in a clinical setting, it is tempting to attribute low scores to the sequelae of mTBI, particularly if the individual is reporting injuries with certain characteristics thought to indicate a more severe injury, such as LOC or PTA. However, this study suggests that psychiatric symptoms, not mTBI characteristics, are associated with cognitive performance across domains. Therefore, caution needs to be taken when attributing cognitive dysfunction to mTBI characteristics, as other potential causes such as psychiatric comorbidities should be considered first, particularly since psychiatric symptoms can often be successfully treated. A misattribution of cognitive symptoms to mTBI rather than to psychiatric etiologies can be detrimental to a patient's healthcare because it may promote negative expectations for recovery, lead to inappropriate treatment strategies, and/or fail to address the true underlying condition (Hoge et al., 2009).

The lack of group differences and the generally average performance across groups is consistent with the expectation that mTBI, regardless of qualitative and quantitative characteristics, should not have a long-term impact on cognitive functioning in most cases. Previous studies have examined mTBI in football players and civilian samples and found that PTA and LOC were not associated with cognitive functioning immediately post-injury (Iverson, Lovell, & Smith, 2000; Lovell, Iverson, Collins, McKeag, & Maroon, 1999; McCrea, Kelly, Randolph, Cisler, & Berger, 2002). This study extends these findings to a military population.

Accurately diagnosing mTBI can be challenging for both clinicians and researchers working with this population. As Iverson, Caplan, and Bogner (2010) point out, TBI screening data should be interpreted with caution given that a high number of false-positives is inherent to the screening process. Military and VA hospitals have begun to implement more detailed screening methods to identify service members at risk for a TBI. While increased sensitivity can increase the number of veterans accurately diagnosed with mTBI, a lack of specificity can lead to increased false-positive diagnoses. Post-concussive symptoms are not unique to mTBI and even healthy adults endorse high rates of post-concussive symptoms (Iverson & Lange, 2003). In addition, certain mTBI characteristics such as disorientation have low specificity and can occur for several reasons other than head injury, including exposure to a traumatic event, stress, and sleep deprivation, which can lead to false-positive diagnoses. Therefore, the group of individuals with disorientation only may be more heterogeneous and overly inclusive with respect to etiology and thus less likely to experience mTBI-related cognitive difficulties. However, the results of this study do not support this hypothesis.

Subjective Cognitive Functioning

Injury characteristics were associated with subjective ratings of cognitive functioning, although most of these relationships were no longer significant once psychiatric symptoms were controlled. After accounting for psychiatric symptoms, a longer time since injury was associated with higher ratings of subjective decision-making difficulties. In addition, individuals reporting PTA and/or LOC endorsed more memory difficulties than individuals who reported disorientation only. Of note, injury characteristics were not associated with neuropsychological performance, which suggests that some injury characteristics may lead to an increase in perceived deficits despite having no significant effect on objective cognitive abilities. This might occur for multiple reasons. First, expectations can play a role in symptom reporting and anticipation of symptoms following TBI may contribute to the expression of post-concussive symptoms (Hoge et al., 2009; Mittenberg, DiGiulio, Perrin, & Bass, 1992; Suhr & Gunstad, 2005). Veterans who experience more severe head injuries may have increased expectations for symptoms. The significant influence that expectations can have on post-concussive symptoms illustrates the importance of clinicians emphasizing an expectation for full recovery to their patients.

In addition, it is not entirely surprising that injury characteristics were variably associated with cognitive ratings given that these data were gathered by self-report and therefore prone to subjectivity on the part of the individual. Individuals have idiosyncratic thresholds for reporting the presence and severity of symptoms which can affect self-report across multiple domains (e.g., psychiatric functioning, cognitive functioning, injury characteristics), leading to correlations amongst various types of self-report data. Consistent with this, veterans with at least one service-connection were more likely to report subjective cognitive difficulties despite no differences in actual cognitive performance compared to non-service connected peers. Not surprisingly, this suggests that individuals who endorse more TBI symptoms are also more likely to seek and/or receive service-connection for TBI and other conditions. This raises concerns about the effects of secondary gains on symptom reporting, although there were no differences in objective cognitive performance between these two groups.

This study also provided replication of previous findings that subjective cognitive functioning is not associated with objective cognitive performance once psychiatric symptoms are taken into account. This can have significant clinical and research implications. While self-report data can be useful to understand how an individual perceives his or her ability to function in the environment, perceptions of cognitive deficits do not always indicate a true cognitive impairment and should therefore be interpreted with caution. This suggests that self-report is not an appropriate substitute for neuropsychological testing when gathering information on cognitive functioning in both clinical and research settings. Even a brief neuropsychological screen can be useful to gain a more objective view of true cognitive abilities.

Psychiatric Functioning

Psychiatric symptoms were highly prevalent, with 90% of participants endorsing clinically significant psychiatric symptoms. These high rates of psychiatric comorbidities may reflect pre-injury characteristics (e.g., pre-existing mood disorders), exposure to psychologically stressful events during deployment, and/or the biomechanics of TBI (e.g., pathophysiological disruptions that lead to emotional dysregulation; Silver, McAllister, & Arciniegas, 2009).

Psychiatric symptoms were associated with reduced neuropsychological performance and it may be that some individuals experience cognitive difficulties due to psychiatric comorbidities yet mistakenly attribute these difficulties to mTBI. Given the high prevalence of psychiatric symptoms in this sample, it may also be that psychiatric symptoms masked any subtle effects that mTBI characteristics may have on cognitive performance. Although examining this relationship in a psychiatrically healthy sample may have directly addressed this relationship better, excluding for psychiatric symptoms would have severely limited the external validity and generalizability of the study.

Psychiatric functioning was also associated with self-reported cognitive ratings. Mood symptoms can lead to negative self-concept, a low sense of self-efficacy, and a tendency to catastrophize (Arnstein, Caudill, Mandle, Norris, & Beasley, 1999; Comunian, 1989; Southwick, Yehuda, & Giller, 1991; Sullivan & D'Eon, 1990), any of which can lead to negative self-report biases. Adequate treatment of psychiatric symptoms may contribute to improved perceptions of functioning in these individuals.

Psychiatric symptoms were associated with mTBI characteristics with the consistent finding that individuals with LOC and/or PTA reported more symptoms of PTSD, anxiety, and depression than individuals who only reported disorientation. Thus, veterans who reported more severe injuries also reported more psychological distress. This is consistent with earlier findings that an increase in PTSD symptoms is associated with an amplification of memory for combat-related traumatic events over time (Southwick, Morgan, Nicolaou, & Charney, 1997). The findings that psychiatric symptoms mediated some of the relationships between injury characteristics and subjective cognitive functioning illustrate the importance of considering psychiatric symptoms in cognitive research.

Limitations

This study is limited in its ability to generalize to the entire mTBI population given that this sample only represents veterans experiencing current post-concussive symptoms seeking VA healthcare services. Because a service member must endorse current post-concussive syndromes to screen positive, the TBI screen is not necessarily screening for the occurrence of mTBI but rather for the presence of post-concussive symptoms. Therefore, individuals who sustained an mTBI but do not experience residual symptoms would likely not be included in this research sample. Despite a recruitment bias, this study sample was drawn directly from the population of veterans presenting for evaluation in a TBI clinic and therefore these findings are directly relevant to healthcare professionals working in this setting.

Psychiatric symptoms were also deduced directly from psychometric measures rather than from psychiatric diagnosis based on formal psychiatric evaluation or structured interview. It is possible that there may be differential patterns of neuropsychological performance between such potential formal diagnoses. Unfortunately, in this clinic-based population, such extensive measures were not feasible and relationships between differential diagnoses and expression of cognitive inefficiency remain a subject for future studies where such resources might be available. In addition, participants in the current study were screened for poor effort using two one brief effort measure and one embedded measure. A comprehensive evaluation of effort would have been ideal but was not feasible within the time constraints of the clinical evaluation. Therefore, the study sample may have contained some individuals with suboptimal effort that was not detected by the effort measures used in the study.

Finally, the mTBI data in this study were based on patient report, which has inherent limitations. Relying on self-report of injury characteristics can be problematic because without independent corroboration, identifying the occurrence and duration of an injury episode is heavily reliant on self-report estimates and best guesses. While this can be problematic in any clinical setting, it is particularly relevant to the VA system given that corroborating information from eyewitness information is rarely available to VA clinicians (Iverson et al., 2010). In a civilian setting, emergency room records or other medical documentation pertaining to the injury may be available. However, record sharing between the military (where the injuries occur) and the VA system (where the injuries are assessed) is less than ideal, making corroborative and objective information difficult for VA clinicians to obtain. In addition, the VA TBI Evaluation Template, like many head injury rating scales, requires an individual to make a distinction between PTA and LOC, which is often very difficult for the individual to do and may lead to inaccurate data. Furthermore, studies have shown that self-reported memory for combat-related traumatic events is highly variable over time (Southwick et al., 1997). Therefore, the limitations of self-report data to make diagnoses and draw conclusions need to be appreciated by clinicians working with this population.

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