EFFORT AND COMMUNITY LEVEL OUTCOME IN VETERANS WITH A HISTORY OF MILD TRAUMATIC BRAIN INJURY

A Dissertation

Presented to

The Faculty of the Department

of Psychology

University of Houston

In Partial Fulfillment

Of the Requirements for the Degree of

Doctor of Philosophy

By

Sara M. Lippa

August, 2012

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ABSTRACT

Objective: To determine how demographics, injury variables, neuropsychological and behavioral variables, service connection status, and performance on symptom validity measures are related to community level outcome in veterans with a history of mild traumatic brain injury (TBI).

Participants and Methods: One hundred seventeen consecutive veterans with a history of mild TBI, 45.5 months post deployment completed the MPAI Participation Index, MMPI-II, PCL, ASSIST, HIT-6, CVLT-II, PASAT, Trail Making Test, and six symptom validity measures as part of larger neuropsychological batteries. Between groups ANOVAs, chi square goodness of fit, linear regressions, and multinomial logistic regressions were conducted to test specific hypotheses.

Results: The models significantly predicted general community participation, but not employment level. Symptom validity, PTSD, and headache interference were all related to community level outcome; however, loss of consciousness, age, time since deployment, substance use, PASAT, Trail Making Test performance, and service connection status were unrelated to community level outcome. Symptom validity interacted with CVLT-II performance to predict MPAI Participation Index.

Conclusions: This study highlights the importance of assessing symptom validity in clinical cases of mild TBI and in clinical research studies involving mild TBI patients. It also supports the treatment strategy of addressing current comorbid conditions, such as PTSD and headaches, rather than focusing solely on the remote history of mild TBI.

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Title: Effort and Community Level Outcome in Veterans with a History of Mild Traumatic Brain Injury

Traumatic brain injury (TBI) is a relatively common problem in the Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) population, occurring in roughly 15-23% of soldiers (Hoge et al., 2008; Terrio et al., 2009). Many OEF/OIF veterans are now seeking treatment for symptoms through TBI clinics in VA hospitals nationwide. While there has been an increase in research conducted on the cognitive and psychosocial outcomes of veterans returning from deployment in Iraq and Afghanistan, it is unclear to what extent this information is being accurately presented to veterans. Without accurate knowledge of anticipated outcomes, veterans may not know what to expect following a TBI, which may cause worse outcomes following mild TBI. For example, concern has been expressed that education programs intended to provide information on TBI are based largely on knowledge regarding recovery from more severe TBI, potentially creating false expectations of long term disability following combat-related mild and moderate TBI (Hoge, Goldberg, & Castro, 2009). Expectations for long term disability may be further amplified following injuries secondary to blasts, given the considerable media attention regarding this mechanism of injury in the absence of clear scientific consensus regarding effects of blast exposure.

While there is some evidence that mild TBI negatively affects cognitive, psychological, neurological, and psychosocial functioning (Roebuck-Spencer et al., 2012; Vanderploeg, Curtiss, Luis, & Salazar, 2007), the preponderance of evidence in the civilian literature suggests cognitive effects dissipate by three months post injury

(Belanger, Curtiss, Demery, Lebowitz, & Vanderploeg, 2005; Binder, 1997; Carroll et al., 2004; Frencham, Fox, & Mayberry, 2005; Schretlen & Shapiro, 2003) and symptom complaints normalize within a year post injury (Carroll et al., 2004). This recovery process is accelerated in athletes (Guskiewicz et al., 2003), presumably because they have high motivation to return to play. Premorbid factors and comorbidities are also important to consider as psychological and medical issues are common in returning veterans with history of mild TBI (Hoge et al., 2008). Compensation issues, which are relevant both in the civilian and veteran populations, negatively affect recovery from mild TBI (Bazarian et al., 2010; Binder & Rohling, 1996; Cook, 1972; Hoge et al., 2008; McCauley, Boake, Levin, Contant, & Song, 2001; Miller, 1961; Paniak et al., 2002).

One context in which compensation issues are prevalent is in the VA health care system where, depending on the severity of their current symptoms, individuals can receive up to $2,769/month (or more if they have a spouse or dependants) for injuries and illnesses related to their military service (U.S. Department of Veterans Affairs, 2011). Many veterans present to VA neuropsychological clinics with the reasonable assumption that their performance on testing may contribute to decisions regarding compensation and pension. Failure of symptom validity tests has been noted to occur in as many as 58% of veterans presenting for neuropsychological testing (Armistead-Jehle, 2010). For these reasons, symptom validity is extremely important to consider when evaluating outcome following mild TBI in veterans.

Many studies have investigated the prevalence of failing symptom validity measures in both civilian and veteran populations, and many have also investigated the relationship between failing symptom validity measures and neuropsychological

performance and/or psychiatric functioning. There has been some indication that failure of symptom validity measures is related to psychiatric outcomes. In a mild TBI clinic where many of the patients were injured in a worker's compensation context or were involved in litigation, premorbid factors, injury characteristics, and cognitive performance were not related to PPCS, but symptom validity measures were related to PPCS (Mooney, Speed, & Sheppard, 2005). To date, however, no studies have investigated the relationship between failing symptom validity measures and community level outcomes. Knowledge about this relationship may be valuable for developing interventions following mild TBI.

As with most acquired injuries, outcome following mild TBI is likely a product of the interaction between physical, psychological, behavioral, and contextual variables, although in the case of mild TBI, injury characteristics likely play a much more limited role in outcome prediction. The high incidence of comorbid conditions and the availability of compensation for persistent postconcussive symptoms serve to complicate the important issue of assessing outcome following service-related mild TBI.

Outcome Following mild TBI

Symptom Complaints

In civilians, the early stages following a mild TBI are associated with subjective complaints of decreased memory, concentration, and mental speed, as well as symptoms of headache, dizziness, fatigue, drowsiness, sensitivity to light or noise, and nausea (McCrea, 2008). Self-reported affective, cognitive, and somatic complaints, collectively known as postconcussive (PC) symptoms, generally resolve within two weeks following a sports related mild TBI, though elevated rates of symptom report following mild TBI

may persist in general adult samples one year post injury or longer (Dikmen, Machamer, Winn, & Temkin, 2005; Hanks, Temkin, Machamer, & Dikmen, 1999). Of note, considerable debate exists over the etiology and persistence of PC symptoms, as the symptoms are non-specific and are frequently reported by individuals with other types of injury (Lees-Haley, Fox, & Courtney, 2001), chronic pain (Iverson & McCracken, 1997), chronic headache (Hollnagl & Norrelund, 1980), and depression (Iverson, 2006). In studies comparing cognitive, psychological, and physical symptoms of head injured patients to patients with other, non-head injuries (Lees-Haley et al., 2001), and to people with no injuries (Gouvier, Uddo-Crane, & Brown, 1988), most symptoms were not reported at significantly different rates. Wang, Chan, and Deng, (2006) found that 45% of healthy college students endorsed five or more PC symptoms.

When these complaints abnormally persist, the patient is said to have persistent postconcussive syndrome (PPCS), a combination of physical, cognitive, and affective symptoms that are present beyond three months post injury. Of patients with mild TBI, less than 5% (Iverson, 2005) develop PPCS. The abnormal persistence of postconcussive symptoms may be associated with other conditions sometimes present in those recovering from mild TBI. Hoge et al. (2008) demonstrated that in soldiers, these lasting PC complaints are more strongly associated with Posttraumatic Stress Disorder (PTSD) than past mild TBI.

Oftentimes, due to lack of accurate information or pre-existing notions of the long-term effects of a brain injury, people may expect to suffer from the effects of a mild TBI for their entire life. Non-head injured individuals have been shown to anticipate PC symptoms following mild TBI without any prior knowledge or observation of symptoms

following mild TBI (Mittenberg, DiGiulio, Perrin, & Bass, 1992). After experiencing a mild TBI, these latent expectations may cause an individual to become hypervigilant to otherwise normal symptoms and to misattribute these symptoms to the history of mild TBI. This "expectation as etiology" hypothesis has been proposed with a more general "good old days" hypothesis (Gunstad & Suhr, 2001), which holds that experiencing any negative event can cause a person to underestimate the prevalence of symptoms they experienced prior to the negative event and overestimate the difference in their functioning before and after the event.

Cognitive Effects

The most frequently identified cognitive effects in the acute period of recovery following mild TBI include problems recalling material, slowed processing speed, and decreased attention (Carroll et al., 2004). Frencham et al. (2005) found that neuropsychological tests of attention and working memory, processing speed, memory, and executive functions appear to be the most sensitive to mild TBI, though overall this effect was small and decreased as time since injury increased. Cognitive effects (i.e., neuropsychological performance) typically associated with civilian mild TBI generally resolve within several weeks to three months post-injury (Belanger et al., 2005; Binder, 1997; Carroll et al., 2004; Frencham et al., 2005; Levin, Mattis, & Ruff, 1987; Schretlen & Shapiro, 2003), except in litigation samples, where cognitive functioning tends to worsen with time (Belanger et al., 2005). With athletes, good recovery is typically seen, with no deficits on neuropsychological tests within 5-10 days post injury (Bleiberg et al., 2004; Lovell, Collins, Iverson, Johnston, & Bradley, 2004; Macciocchi, Barth, Alves, Rimel, & Jane, 1996; McCrea et al., 2003; Pellman, Lovell, Viano, Casson, & Tucker,

2004). One prospective study of collegiate athletes found cognitive functioning returned to baseline functioning within five to seven days post-injury (Guskiewicz et al., 2003). Faster recovery in athletes, relative to civilians, could be a result of less severe injuries, or alternatively, greater motivation to return to their premorbid functioning. For this reason, it is particularly important to consider possible biases in various study samples, including differences in motivation.

Community Participation

With mild TBI, the most relevant community level outcome may be return to work. It is estimated that mild TBI accounts for approximately 1% of all emergency room visits (McCrea, 2008). Lost productivity following mild TBI is said to account for 44% of the financial costs associated with brain injury in the United States due to its high incidence (Max, MacKenzie, & Rice, 1991). Studies investigating return to work following mild TBI have had mixed findings, with some studies finding no differences in rates of return to work between mild TBI patients and non-brain injured controls at 6 months post injury (Boake et al., 2005; Dikmen, McLean, & Temkin, 1986; Friedland & Dawson, 2001), and others reporting statistically significant differences between groups (Stulemeijer et al., 2006; Vanderploeg, Curtiss, Duchnick, & Luis, 2003; Vanderploeg et al., 2007). While indicators of injury severity do not appear to affect likelihood of return to work in mild TBI patients (Hanlon, Demery, Martinovch, & Kelly, 1999; Harad & Kerstein, 1992; Hinton-Bayre & Geffen, 2002), return to work does appear to be influenced by a combination of physical, psychological, and behavioral variables in people with a history of mild TBI. Of course, factors external to the individual, such as the economic climate and job market can affect return to work as well, and should be

considered when comparing studies. The economic downturn that began in 2008 may make it even more difficult for individuals with histories of mild TBI to return to their jobs or find new work, as their old positions and potential new positions are less likely to be available.

Overall, studies show that 12-20% of mild TBI patients do not return to work within a year after their injury (Binder, 1997; Dikmen et al., 1994; Hurt, 2000; Stambrook, Moore, Peters, Deviaene, & Hawryluk, 1990; Van der Naalt, van Zomern, Sluiter, & Minderhound, 1999). Rates of return to work tend to be lower in samples where financial compensation is an issue. In Ontario, where only individuals with serious and/or permanent injury may receive insurance reimbursement, only 42% of mild TBI patients returned to work 6-9 months post injury (Ruffolo, Friedland, Dawson, Colantonio, & Lindsay, 1999). While the authors did not attribute this low rate of return to work to litigation status, this variable was not collected. In Quebec, where parties incapacitated in automobile accidents are compensated 90% of their net income so long as their regularly scheduled disability assessments continue to warrant compensation, Nolin & Heroux (2006) found that 22% of mild TBI patients had not returned to work within 1-3 years post-injury. Only number of symptoms reported at follow-up (and not age, gender, Glasgow Coma Scale (GCS) score, length of posttraumatic amnesia (PTA), retrograde amnesia, or total symptoms at emergency room) was significantly related to vocational status.

Return to work does not necessarily imply dissipation of PC symptoms. Of those who return to work, many continue to report PC symptoms. Nolin and Heroux (2006) found that 48.5% of participants who returned to work endorsed at least one PC symptom

one to three years post mild TBI. While this percentage is impressive, it is important to note that this sample was not compared to the normal population. A study in England (Gilworth, Eyres, Carey, Bhakta, & Tennant, 2008) found that 25 of 33 patients with mild and moderate brain injuries had returned to work by 4-6 months post-injury. While a high number of these patients returned to work, many difficulties were reported in individual interviews. These included difficulty returning to work, persistent symptoms (e.g., problems with concentration, executive functions, and memory), lack of support and doubt from colleagues and employers, and pressure to return to work.

Measurement Issues

It is critical to consider methodological issues when analyzing and comparing studies on outcome following mild TBI. Some studies use highly selective samples, which can bias results. Existing research also suffers from poor comparison or reference groups, lack of investigation of reasons for attrition and consideration of how this affects results, lack of consideration of sources of information biases (e.g., patients with a history of mTBI may tend to underestimate their pre-injury symptoms (Ferguson, Mittenberg, Barone, & Schneider, 1999)), and inadequate power to find significant results (Carroll et al., 2004).

The study of mild TBI becomes more complex with the use of retrospective self-report and as time since injury increases, as is commonly the case with veterans. Veterans' history of mild TBI if often not carefully assessed for months or years following their injury and rarely, if ever, is additional information about combat-related mild TBI injury characteristics available for review in clinical settings, as careful documentation of acute injury characteristics may not be a priority in the combat theater.

Problems with self-report include differences in willingness to admit problems, symptom exaggeration, and the fallibility of memory (Loftus, Levidow, & Duensing, 2002). Despite this, patient self report, as facilitated by clinical interview, is currently the "gold-standard" for the historical diagnosis of a mild TBI (Corrigan & Bogner, 2007, p. 316). While current symptom complaints are neither necessary for, nor indicative of, a diagnosis of history of mild TBI (Brenner, Vanderploeg, & Terrio, 2009), the screener used at the VA requires endorsement of current symptoms for referral for neuropsychological evaluation of mild TBIs which may have occurred years earlier (Belanger, Uomoto, & Vanderploeg, 2009b). Therefore, only patients with both a possible history of mild TBI and current symptoms (which are nonspecific to mild TBI ((Gouvier, Uddo-Crane, & Brown, 1988; Hollnagl & Norrelund, 1980; Iverson, 2006; Iverson & McCracken, 1997; Lees-Haley et al. 2001; Wang et al., 2006)) screen positive, while patients with histories of mild TBI who are not currently reporting symptoms have a negative screen. Certainly, it is important to address veterans' current symptoms and the screener is a good way to identify veterans with current symptoms; however, the screener may lead both the patient and the provider to assume that there is a causal link between the history of mild TBI and the current symptoms, when, in all likelihood, all symptom complaints caused by the injury should be resolved in the vast majority of individuals by the time a veteran presents to the VA several months or years post injury.

It is also important to consider that prediction of outcome depends on much more than mild TBI severity or mechanism of injury. Demographics, psychological and medical issues, prior brain damage, neural reserve, social support, and mild TBI educational programs can all affect outcome following mild TBI.

Barriers and Facilitators to Good Outcome Following mild TBI

Demographic Differences

Certain demographics contribute to differences in symptom complaints, cognitive sequelae, and functional outcome in mild TBI. Gender is frequently found to be related to both functional outcome (e.g., return to work, participation in activities, quality of life) and symptom report following mild TBI. While animal studies tend to report better outcomes in females than males with TBI (Bramlett & Dietrich, 2001; O'Connor, Cernak, & Vink, 2003; Wagner et al., 2004), human studies tend to report better outcomes in males than females with mild TBI (Bazarian & Atabaki, 2001; Bazarian et al., 1999; Covassin & Bay, 2012; Jensen & Nielsen, 1990; McCauley et al., 2001; Rutherford et al., 1977, 1979), though this is not always the case (Fenton, McClelland, Montgomery, MacFlynn, & Rutherford, 1993). In a recent study (Bazarian, Blyth, Mookerjee, He, & McDermott, 2010), being female was significantly related to PC symptom severity, but not number of days to return to work or number of work days missed (all reported via telephone interview).

Outcome following TBI has consistently been found to be related to age, with elderly patients at increased risk for poor outcome than younger patients (Braakman, Gelpke, Habbema, Maas, & Minderhoud, 1980; Choi, Ward, & Becker, 1983; Gomez et al., 2000). Others have found increasing age to be related to increased PC symptoms (Bazarian et al., 2010; Fenton et al., 1993) and lower rates of return to work (Drake, Gray, Yoder, Pramuka, & Llewellyn, 2000) in patients with a history of mild TBI. Mosenthal et al. (2004) found elderly patients had statistically, though not necessarily clinically, worse functional outcomes at discharge and 6 months post mild TBI. In

contrast Stapert, Houx, De Kruijk, Ponds, and Jolles (2006) did not find age related to outcome in mild TBI and McCauley et al. (2001) found no relationship between age and PPCS.

While many studies have shown minorities are more likely than Whites to have poor outcomes following TBI (Arango-Lasprilla et al., 2007; da Silva Cardoso, Romero, Chan, Dutta, & Rahimi, 2007; Hart, Whyte, Polansky, Kersey-Matusiak, & Fidler-Sheppard, 2005; Rosenthal et al., 1996; Sander et al., 2009; Sherer et al., 2003; Staudenmayer, Diaz-Arrastia, de Oliveira, Gentilello, & Shafi, 2007), relatively few studies have investigated the effect of race on mild TBI outcome. Of the studies that exist, many have found no relationship between race and functional outcome (Burnett, Silver, Kolakowsky-Hayner, & Cifu, 2000; Rosenthal et al., 1996). Brown, McCauley, Levin, Contant, & Boake (2004) found that African American patients with a history of mild TBI reported worse physical functioning, while Hispanic patients with a history of mild TBI reported less social support three months post injury. In contrast to this finding of worse outcome for minorities, Hispanics with a history of mild TBI were found to be less likely than other racial groups to develop PC symptoms three months post injury (McCauley et al., 2001). Very few studies have investigated the relationship between socioeconomic status (SES) and outcome, but of those that have, many have found SES is inversely related to outcome (Bazarian et al., 2010; Rutherford, 1989; Sander et al., 2009).

The neural reserve hypothesis, that people with larger brain reserve are able to endure more neuronal loss before clinical expression of a brain disease than people with smaller brain reserve (Satz, 1993), has been hypothesized to explain why certain people

have worse outcomes than others following mild TBI (Bigler, 2007). IQ is offered as a strong measure of neural reserve as it correlates with neuronal branching (Nebes et al., 2005) and brain volume (Wickett, Vernon, & Lee, 2000). Education has also been suggested as a predictor of neural reserve (Ropacki & Elias, 2003), and both education and IQ have been shown to additively contribute to neural reserve. Indeed, Dawson, Batchelor, Meares, Chapman, and Marosszeky (2007) have shown that there is a negative relationship between IQ and length of PTA, and between education and length of PTA, and suggest that neural reserve may mediate mild TBI outcome. Ropaki and Elias (2003) showed that TBI patients with some of the aforementioned premorbid vulnerabilities demonstrate larger pre-post injury declines in IQ than patients without these vulnerabilities, and suggest that these premorbid vulnerabilities reduce one's neural reserve, leaving one at increased risk of poor outcome following TBI.

Injury Severity, Prior Brain Damage, and Comorbid Psychological and Medical Issues

Prediction of outcome following mild TBI is complicated by ongoing diagnostic controversies (see Appendix A for information on mild TBI diagnostic systems). There have been mixed findings regarding the influence of PTA and loss of consciousness (LOC) on outcome in mild TBI. Some studies have shown that, relative to patients without PTA, patients with PTA are less likely to return to work (Wenden, Crawford, Wade, King, & Moss, 1998), have increased PC symptom report (ibid.), and worse Glasgow Outcome Scale Score (Jennett & Bond, 1975). The majority of studies, however, find no association (Drag, Spencer, Walker, Pangilinan, & Bieliauskas, 2012; Hanlon et al., 1999, Harad & Kerstein, 1992; Hinton-Bayre & Geffen, 2002) between

presence and/or length of LOC or PTA following mild TBI and objective outcome measures. Interestingly, however, Drag and colleagues (2012) found that while presence of LOC was not associated with objective cognitive performance, patients with LOC reported more subjective cognitive complaints than patients with no LOC. Positive Computerized Tomography (CT) findings have been commonly related to worse outcomes (Bazarian et al., 2010; Borgaro et al., 2003; Iverson, 2006; Kashluba et al., 2008; Levin et al., 2008; Williams, Levin, & Eisenberg, 1990) although not always (Hanlon et al., 1999, Hofman et al., 2001; Hughes et al., 2004; McCauley et al., 2001). When positive CT findings are found in mild TBI cases, these cases are generally referred to as complicated mild TBI. Bruising, swelling, and bleeding are present in the CT scans of 7-20% of mild TBI patients presenting to emergency rooms (French & Dublin, 1977; Iverson, Lovell, Smith, & Franzen, 2000; Jeret, et al., 1993; Levin, Williams, Eisenberg, High, & Guinto,1992; Livingston, Loder, Koziol, & Hunt, 1991; Tellier et al., 1999; Borg, Holm, Cassidy et al., 2004). When considering this finding, however, it is important to note that not all patients seek medical attention [with people with less severe injuries being less likely to seek medical attention than people with more severe injuries (Sosin, Sniezek, & Thurman, 1996)]. Iverson (2005) suggests these complicated mild TBIs are more similar to moderate TBIs than noncomplicated mild TBIs.

Due in part to the increased awareness of mild TBI due to the current wars in Iraq and Afghanistan, there has been a growing concern regarding the long-term effects of mild TBI, especially repeated mild TBI, in athletes. Recent case studies have suggested that multiple head injuries result in chronic traumatic encephalopathy, a progressive

dementia characterized by tau pathology throughout the brain (McKee et al., 2009). Despite the heightened interest about this issue in the media, no prospective, well-controlled studies have been conducted in this area (ibid). Sports literature shows that multiple concussions generally do not have a large effect on neuropsychological test performance (Pellman et al, 2004), though they may have some cumulative effects (Collins et al., 2002; Gaetz, Goodman, & Weinberg, 2000; Iverson, Gaetz, Lovell, & Collins, 2004,) and put athletes at an increased risk of future concussions (Guskiewicz et al., 2003; Zemper, 2003). Athletes with persistent problems generally have anxiety in addition to (multiple) mild TBI(s).

Premorbid psychological and medical injuries have also been shown to contribute to the likelihood of a patient with a history of mild TBI developing PCS (Binder, 1986; MacMillan, Hart, Martelli, & Zasler 2002; McCauley et al., 2001; Ponsford et al., 2000). Fenton et al. (1993) found that patients with significant PC complaints were twice as likely to have had chronic social difficulties prior to their mild TBI.

Substance abuse has been reported to be prevalent in as many as 70% of TBI patients, with 33% abusing alcohol, 8.6% abusing one drug and 29% evidencing polysubstance abuse (Drubach, Kelly, Winslow, & Flynn, 1993). Base rates of chronic alcoholism in TBI patients has been said to range from 25% to 79% (Bogner, Corrigan, Mysiw, Clinchot, & Fugate, 2001; Corrigan, Bogner, Mysiw, Clinchot, & Fugate, 2001; Kolakowsky-Hayner et al., 1999). Substance abuse has been shown to affect indicators of injury TBI severity (Bigler et al., 1996; Brickley & Shepherd, 1995; Gurney et al., 1992; Kaplan & Corrigan, 1992) and outcome following TBI (Bogner et al., 2001, Charness, 1993; Corrigan et al., 2001; Rönty, Ahonen, Tolonen, Heikkila, & Niemela, 1993; Ruff et

al., 1990; Sabhesan, Arumugham, Ramasamy, & Natarajan, 1987). Overall, performance on neuropsychological testing does not appear to differentiate between the effects of substance use and mild TBI (Barker et al., 1999; Iverson, Lang, & Franzen, 2005; Lange, Iverson, & Franzen, 2008), though few studies have looked at how the combination of mild TBI and substance abuse affects outcome.

Post Injury Factors

As mentioned previously, PC symptoms are not unique to mild TBI, but occur in patients with depression, PTSD, headache, and chronic pain. These may be pre-existing in patients with a history of mild TBI reporting PC symptoms, or they may be related to the mild TBI or comorbid conditions. While only a small number of mild TBI patients develop PPCS, a large percentage of these patients have comorbid psychiatric diagnoses and/or pain (McCauley et al., 2001; Mooney et al., 2005). Depression commonly persists following mild TBI, even after one has regained their premorbid cognitive functioning (Levin, 1987). Depression correlates with TBI patients' cognitive complaints (Fann, Katon, & Vomoto, 1995; Gass & Apple, 1997; King, 1996) and objective cognitive measures (Bornstein, Miller, & van Schoor, 1989; Gass & Apple, 1997; MacNiven & Finlayson, 1993).

While cognitive effects of mild TBI are expected to decrease over time (Frencham et al., 2005; Schretlen & Shapiro, 2003), PTSD has been shown to result in lasting cognitive symptoms (Brenner et al., 1995; Vasterling, Brailey, Constans, & Sutker, 1998). Friedland & Dawson (2001) found that in civilians involved in motor vehicle accidents, PTSD accounts for more of the disability, decreased satisfaction with their reintegration to normal living, and likelihood of return to work than head injury. In

contrast, Brenner et al. (2010) found that of veterans with a history of mild TBI secondary to blast injury, there was no difference in neuropsychological test performance based on whether veterans reported PC symptoms following (acutely or postdeployment) their injury or whether they met criteria for PTSD at the time of the assessment. Posttraumatic stress disorder and depression have been shown to mediate the relationship between mild TBI severity (i.e., presence of LOC) and general health, number of medical visits, number of missed workdays (Hoge et al., 2008), as well as psychosocial difficulties (Pietrzak, Johnson, Goldstein, Malley, & Southwick, 2009).

Comorbid extracranial injuries also appear to be related to worse outcome in civilian mild TBI (Bazarian et al., 2010; Friedland & Dawson, 2001; Stulemeijer et al., 2006). Interestingly, however, of service members with a history of mild TBI secondary to blast injury, additional bodily injuries may be paradoxically protective against the development of persistent postconcussive symptoms. Of 274 male service members with blast related mild TBI, 144 of which had other physical injuries, service members with both mild TBI and other injuries reported lower severity of PC and posttraumatic stress symptoms an average of 13 weeks post injury than service members with mild TBI only (Kennedy, Cullen, Amador, Huey, & Leal, 2010). The authors hypothesized that an "invisible wound" (i.e., mild TBI) creates more ambiguity regarding symptom etiology, and results in increased symptom report.

While comorbid medical and psychological issues increase the likelihood of poor outcome following mild TBI, adequate social support appears to serve as a protective factor following mild TBI. Decreased social support is related to depression in patients with TBI (Elsass & Kinsella, 1987; Karpman et al., 1985; Kinsella, Ford, & Moran, 1989;

Kozloff, 1987; Prigatano, 1986; Weddell, Oddy, & Jenkins, 1980). Social support has been shown to be related to general health in veterans (Ren, Skinner, Lee, & Kazis, 1999). Psychosocial functioning (i.e., social interaction, emotional behavior, alertness, and communication) is lower in motor vehicle accident victims with mild TBI than persons injured in motor vehicle accidents but with no TBI (Friedland & Dawson, 2001). Social interaction has been shown to be positively related to return to work following mild TBI (Ruffolo et al., 1999).

Early educational intervention and reassurance also appear to positively affect recovery (Borg, Holm, Peloso et al., 2004; Ponsford et al., 2001, 2002; Paniak, Toller-Lobe, Reynolds, Melnyk, & Nagy, 2000; Paniak, Toller-Lobe, Durand, & Nagy, 1998), with patients receiving education following their injury reporting fewer symptoms than patients who did not receive such treatment (Minderhoud, Bouelens, Huizenga, & Saan, 1980; Ponsford et al., 2002; Relander, Troupp, & af Björkensten, 1972; Wade, King, Wenden, Crawford, & Caldwell, 1998). Patients' perceptions of their injury severity and expected length of PC symptoms appear to relate to outcome (Whittaker, Kemp, & House, 2007). It is recommended patients receive structured educational information, including information regarding the injury, common symptoms and coping strategies, expectation of good outcome, and where additional support can be received within one week of their mild TBI (Borg, Holm, Peloso et al., 2004).

Neuropsychological evaluations are often used to determine whether or not a patient is experiencing residual cognitive deficits from TBIs. While neuropsychological evaluations are often useful for uncovering cognitive and behavioral deficits that may not appear in functional images of the brain or in neurological exams, patients may not

always be putting their full effort into tasks or may even be consciously underperforming. This may be due to the patient not being invested in the outcome of the testing; however, oftentimes it is due to some specific external incentive to perform poorly. There are many reasons why patients might want to appear more impaired than they actually are, most commonly to avoid a variety of social, financial, or personal consequences (Lezak, Howieson, & Loring, 2004). Neuropsychologists have developed two means of detecting problems with symptom validity: symptom exaggeration detection and effort testing. Symptom exaggeration detection examines fabrication or overreporting of existing symptoms, generally by the use of questions embedded in self-report questionnaires or in stand-alone measures. Effort testing uses neuropsychological tests of effort (although these are not necessarily measuring "effort" in the true sense of the word), which detect likely conscious underperformance. Current symptom validity tests often test both "intent to perform poorly," and "effort" and collapse these two constructs onto a single dichotomous outcome variable, which is important for clinicians and researchers to consider this when interpreting SVT results (Frederick & Bowden, 2009).

Generally, financial gain is thought to be the one of the main motivators behind symptom validity issues, with studies showing that decreased performance on neuropsychological measures is associated with larger financial compensation (Bianchini, Curtis, & Greve, 2006; Binder & Rohling, 1996). Furthermore, financial compensation has been shown to play a large role in probable symptom exaggeration (Binder & Rohling, 1996; Cook, 1972; Miller, 1961; Paniak et al., 2002; Reynolds, Paniak, Toller-Lobe, & Nagy, 2003). However, recently Silver (2012) discussed how expectations of

prognosis, stress, stereotype threat, anger, revenge, and loss aversion can all contribute to symptom validity issues as well.

The issue of symptom validity and TBI in civilians is especially important because many TBIs are caused by motor vehicle accidents, on the job injuries, or other situations that may lead to lawsuits. Financial incentives to exaggerate symptoms are also present within the VA health care system, as compensation may be available if they demonstrate residual cognitive deficits secondary to a history of brain injury. While roughly 40% of civilians involved in neuropsychological evaluations for mild TBI lawsuits fail symptom validity tests (Larrabee, 2003a; Mittenberg, Patton, Canyock, & Condit, 2002), the rate may be even higher in veterans with a history of mild TBI reporting for neuropsychological evaluation (58%), and is especially high in those with service connection status or a previous depression diagnosis (Armistead-Jehle, 2010). It is important to note, however, that the percentage of patients categorized as demonstrating suboptimal effort varies even within veterans. Whitney, Shepard, Williams, Davis, & Adams (2009) found that only 17% of veterans failed symptom validity measures, which stands in stark contrast to the 58% failure rate found by Armistead-Jehle (2010). As both studies were of polytrauma samples and used the same measure of symptom validity, this range likely reflects differences in referral practices (e.g., referring physicians, referral rates, number of veterans presenting to each site) between sites. Though symptom validity failure rate varies even between similar clinics in different locations, it is important to consider symptom validity when interpreting neuropsychological test results and recommending treatment plans, especially when external incentive to exaggerate or fabricate symptoms is present.

Extensive research demonstrates that failure of symptom validity measures is related to neuropsychological performance (Constantinou, Bauer, Aahendorf, Fisher, & McCaffrey, 2005; Green 2007; Green, Rohling, Lees-Haley, & Allen, 2001; Stevens, Friedel, Mehren, & Merten, 2008). Less clear is the relationship between failed symptom validity measures and psychiatric outcomes. In a study wherein most of the participants were injured in a worker's compensation context or were involved in litigation, Mooney et al. (2005) found that while premorbid factors, injury characteristics, and cognitive performance were not related to PPCS, failed symptom validity measures were related to increased PPCS. Some studies, however, have found no relationship between pursuit of secondary gain and outcome. McCauley et al. (2001) found no relationship between litigants with a history of mild TBI or persons receiving compensation for their past mild TBI and the development of PPCS three months post injury. No studies have investigated the impact of symptom validity on community level outcome.

The cumulative disadvantage hypothesis holds that many outcomes following disease, illness, or injury are not solely dependent on that incident, but rather are dependent on multiple factors related to the injury. This hypothesis seems to apply to community level outcome in civilians with a history of mild TBI, as return to work is postulated to be dependent on multiple factors, including premorbid characteristics, injury characteristics, comorbidities, and environmental factors. Therefore, all of these factors must all be considered when predicting outcome (Shames, Treger, Ring, & Giaquinto, 2007). Similarly, the development of PPCS is the result of multiple stressors (e.g., emotional, cognitive, physical, social, financial, and vocational; Ruff, Camenzuli, & Mueller, 1996). When these stressors combine with each other and with premorbid

psychological and medical factors, they result in increased disability (Evered, Ruff, Baldo, & Isomura, 2003). This hypothesis suggests it is necessary to employ a comprehensive approach, investigating all of a person's past and present stressors, when evaluating patients with poor outcomes following mild TBI. In veterans, factors additional to the mild TBI may be even more important to consider, as these individuals are at increased risk for psychological disorders and adjustment issues (Hoge et al., 2008).

Mild Traumatic Brain Injury in Veterans

Although the science of mild TBI has matured considerably over the last 50 years (Iverson et al., 2009), the extent to which knowledge gained largely through studies of civilians and athletes can be generalized to the veteran population is unclear. The mechanisms of combat related mild TBI and the milieu in which it occurs are appreciably different from those of the civilian population. Increased use of improvised explosive devices (IEDs) has caused a higher rate of blast injuries in military personnel deployed during OEF/OIF compared to veterans deployed during previous missions. In an analysis of the injuries incurred by one battalion operating in Iraq in March through August 2004, Gondusky and Reiter (2005) found that 97% of injuries were caused by blasts. Given the large number of blast injuries in recent wars, current research has examined whether outcome from mild TBI secondary to blast injury differs from outcome from mild TBI secondary to non-blast injury (e.g., falls, motor vehicle accidents). Blast injury does not appear to differentially affect neuropsychological performance or PC symptom report in comparison to other mechanisms of mild TBI (Belanger et al., 2009a; Lange et al., 2012; Lippa, Pastorek, Benge, & Thornton, 2010; Luethcke, Bryan, Morrow, & Isler, 2011;

Wilk et al., 2010). Blast related mild TBI, however, is related to increased posttraumatic stress symptom severity and posttraumatic stress symptoms may account for a majority of PC symptoms regardless of mechanism of mild TBI (Belanger et al., 2011; Hoge et al., 2008; Lippa et al., 2010). This is not always the case, however, as Kennedy, Leal, Lewis, Cullen and Amador (2010) and Leuthcke and colleagues (2011) found no relationship between mechanism of injury and overall posttraumatic stress symptom report. While blast injury was related to increased PC symptom report, posttraumatic stress symptoms mediated this relationship (Hoge et al., 2008). It has been suggested that blast injury serves as a proxy for combat intensity, with service members exposed to blasts being exposed to more dangerous combat situations in general, and subsequently being at increased risk for developing posttraumatic stress symptoms (Hoge et al., 2008; Lippa et al., 2010).

As many veterans with mild TBI also have PTSD, the influence of PTSD on outcome is particularly important to consider in studies evaluating outcome of mild TBI in veterans. While there has been a large debate in the civilian literature (Bryant, 2001; Harvey, Brewin, Jones, & Kopelman, 2003; Klein, Caspi, & Gil, 2003) regarding whether the development of PTSD from a TBI with loss of consciousness is possible (since it should be difficult to remember the traumatic event), veterans are likely to have PTSD from combat in general, and not simply from the traumatic event causing the TBI. In combat theater, it seems that combat intensity would be related both to the development of PTSD and to the incurrence of a TBI. It is also possible that there is a complex interaction between PTSD and mild TBI in the combat theater, with the presence of PTSD making the brain more sensitive to a mild TBI, or alternatively, a mild

TBI making a person more likely to develop PTSD. Other physical, psychological, and behavioral issues could further complicate this relationship. Veterans with PTSD have increased somatic symptoms, miss more days from work, and have lower general health than veterans without PTSD (Hoge, Terhakopian, Castro, Messer, & Engel, 2007; Jakupcak, Luterek, Hunt, Conybeare, & McFall, 2008). They also demonstrate more instability of affect and self esteem than veterans without PTSD (Kashdan, Uswatte, Steger, & Julian, 2006). Veterans with PTSD have even been found to demonstrate increased retroactive interference, as compared to demographically matched controls, causing them remember fewer words from a list after a short delay during which another list is presented (Yehuda, 1995).

The Present Study

The present study aims to determine how cumulative disadvantage from certain demographic variables, injury variables, psychological and behavioral variables, service connection status, performance on symptom validity measures, and some neuropsychological test scores in veterans with a history of mild TBI presenting to VA medical centers are related to community level outcome (an estimated average of 3 years post injury). The independent variable of greatest interest is that of symptom validity test failures, as its relationship with community level outcome following mild TBI has not previously been investigated. It is crucial to determine which variables contribute most to our cumulative disadvantage model in terms of community level outcome so that interventions can be targeted towards the symptoms and disorders most affecting outcome.

The following hypotheses will be explored:

Hypothesis 1: As has been found previously in the literature, depression, posttraumatic stress symptoms, substance use, and headache interference will be inversely related to community level outcomes (i.e., employment, general community participation) while presence/absence of LOC and neuropsychological test scores will be unrelated to community level outcomes in a convenience sample of veterans over 3 years post injury.

Hypothesis 2: The number of symptom validity tests failed will be inversely related to community level outcomes (i.e., employment and general community participation), even when taking into account presence/absence of LOC, depression, posttraumatic stress symptoms, substance use, headache interference, and neuropsychological test scores in the same sample.

Hypothesis 3: The relation between psychological symptoms, cognitive performance, and community level outcomes (i.e., employment and general community participation) will be dependent upon symptom validity performance. Specifically, in veterans who pass the most specific measure of symptom validity, community level outcome will be inversely related to psychological symptoms, and presence/absence of LOC, and positively related to cognitive performance. The strength of these relations will be attenuated in veterans who fail the most specific measure of symptom validity

Methods

Participants

Data from 117 OEF/OIF veterans consecutively presenting to the Traumatic Brain Injury Clinics at the Houston, Oklahoma City, Salt Lake City, and Muskogee VA Medical Centers were collected in compliance with the regulations of the their respective Committees for the Protection of Human Subjects and Institutional Review, as well as

that of the University of Houston. All data were de-identified by removing names, dates, and any numbers linking the patient to their medical records. Each participant was assigned a study number. Lists linking the study number to participants were kept by the neuropsychologist at each site in an encrypted file.

All participants included in this study were referred for evaluation through a nationwide VA TBI screening process. A referral for evaluation was automatically generated if the veteran endorsed all of the following items: 1) Did you have any injury(ies) during your deployment from any of the following (Check all that apply: blast or explosion, vehicular accident/crash, fragment wound or bullet wound above shoulders, fall), 2) Did any injury you received while deployed result in any of the following (Check all that apply: being dazed, confused or "seeing stars," not remembering the injury, concussion, head injury), 3) Did any of these begin or get worse afterward? (Check all that apply: dizziness, headaches, memory problems, balance problems, ringing in the ears, irritability, sleeping problems), and 4) In the past week, have you had any of the above symptoms? (Check all that apply: dizziness, headaches, memory problems, balance problems, ringing in the ears, irritability, sleeping problems). The screen has been found to have high-internal consistency and positive predictive power, variable test-retest reliability, sensitivity, and specificity, and generally poor negative predictive power (Belanger, Vanderploeg, Sobel, Richardson, & Groer, 2012; Donnelly et al., 2011; Terrio, Nelson, Betthauser, Harwood, & Brenner, 2011; Van Dyke, Axelrod, & Schutte, 2010). It should be stressed that only patients with both a possible history of TBI and current symptoms were referred for evaluation; patients with histories of TBI who were not currently reporting symptoms were not referred for evaluation, and therefore, were not included in this study.

Measures

Predictor measures. The following variables were used as predictors of community level outcome (i.e., employment status and general community participation): time since deployment (defined as the number of months between the veteran's return from deployment and the veteran's evaluation), service connection application status (applying or not applying for service connection or an increase in service connection or petitioning a rejection), injury severity (positive LOC versus no LOC), number of symptom validity tests failed, neuropsychological test scores (i.e., PASAT, CVLT-II delayed recall, and Trails B), depression, posttraumatic stress symptoms, substance use, and headache interference. Depression was measured with the MMPI-2 (Butcher, Dahlstrom, Graham, Tellegan, & Kaemmer, 1989) restructured clinical scale 2. Posttraumatic stress symptoms were measured with the Posttraumatic Stress Disorder Checklist (PCL; Weathers, Huska, & Keane, 1991). Substance use was measured with the Alcohol, Smoking and Substance Involvement Screening Test (ASSIST; WHO ASSIST Working Group, 2002). Headache interference was measured with the Headache Impact Test-6 (HIT-6; Ware, Bjorner, & Kosinski, 2000). Depression, posttraumatic stress disorder, substanceuse, and and headache interference were entered into the models as dichotomous variables, based on established cut-scores inorder to aid in the interpretation of results. The symptom validity and neuropsychological tests, as well as the injury, depression, posttraumatic stress symptom, substance use, and headache measures are described below.

***Injury characteristics*.** The injury questionnaire asks veterans to report the number of deployment-related head injuries, as well as the dates and mechanisms of

injury (e.g., fall, motor vehicle, bullet, or blast). Information regarding the presence and length of alteration in mental status was also solicited (i.e., disorientation, post-traumatic amnesia, and LOC). Veterans who did not report any history of LOC or alteration in mental status secondary to a credible injury mechanism were excluded from the study.

Depression. The MMPI-2 (Butcher et al., 1989) consists of 567 items measuring a variety of psychological characteristics. In addition, it has a number of validity scales, including scales designed to detect over-reporting of symptoms (described below). In an attempt to eliminate the multidimensionality of many of the original scales, Tellegen et al. (2003) developed 10 restructured clinical (RC) scales with no overlapping items, arguably improving the discriminant validity and homogeneity of the scales. The RC scales have been shown to be comparable to the original clinical scales, reliable, and valid in many settings (ibid; Ben-Porath & Tellegen, 2008). Depression was assessed with the RC2 scale. This scale assesses "low positive emotions," or a lack of positively valenced emotional responses. In general, T scores at or greater than 65 on these scales are considered to be consistent with anxiety and depression. Therefore, this score was used as a cutoff in the current study.

Substance use. The ASSIST (WHO ASSIST Working Group, 2002) is an eight item interviewer-administered screening measure of substance use. It investigates both lifetime substance use and the frequency and consequences of substance use in the last three months. It assesses the use of tobacco, alcohol, cannabis, cocaine, amphetamine-type stimulants, inhalants, sedatives, hallucinogens, opioids, and "other drugs." The ASSIST has been shown to have adequate test-retest reliability (ibid.), concurrent validity, construct validity, and discriminative validity (Humeniuk et al., 2008). As

suggested by Henry-Edwards, Humeniuk, Ali, Poznyak, and Monteiro (2003), participants were split into two groups based on their highest specific substance involvement score (calculated by summing questions 2-7 within each drug class; excluding the tobacco scale): those with scores <19 on the alcohol scale and <15 on all other scales (i.e., low risk), and those with scores >18 on the alcohol scale and/or >14 on any other scale (i.e., high risk). Specific substance involvement scores range from 0 to 39 on the alcohol subscale and from 0-33 for all other drug classes.

Headache interference. The HIT-6 (Ware et al., 2000) is a six item scale designed to efficiently measure the amount headaches interfere in one's daily life in a clinical setting. It assesses areas of pain, role functioning, fatigue, cognition, and mood affected by headaches. Each item is rated on a five-point Likert scale ranging from never to always. It has been shown to have high internal consistency and test-retest reliability (Kawata et al., 2005; Kosinski, Bayliss, Bjorner, et al., 2003). Patients were divided into two groups: those with severe headache interference (total scores >59) and those with moderate or less headache interference (total scores up <60).

Posttraumatic stress symptoms. Post Traumatic Stress Disorder symptoms were measured using the National Center for PTSD 17-item checklist (PCL; Blanchard, Jones-Alexander, Buckley, & Forneris, 1996; Bliese et al., 2008; Weathers et al., 1991). Items on this checklist were designed to mirror the diagnostic criteria for posttraumatic stress disorder as defined in the American Psychiatric Association's Diagnostic and Statistical Manual-Fourth Edition (1994). As such, the items measure PTSD symptoms in the domains of re-experiencing, avoidance/numbing, and hypervigilance. Each item is rated on a 1 (not at all) to 5 (extremely) Likert scale. If one or two items were unanswered on

the PCL, the scores for these particular items were estimated using mean filling procedures based on the other items comprising the factor from which the missing items originate. If more than two items were unanswered on the PCL, the participant was excluded from the study. A cut score of 50 has been recommended to indicate a positive screen among veterans (Weathers et al., 1993) and therefore participants were split into two groups, those with scores greater than or equal to 50 and those with scores below 50.

Neuropsychological tests. The California Verbal Learning Test-II (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000), Paced Auditory Serial Addition Test (PASAT; Levin, 1983), and Trail Making Test (TMT; Reitan, 1958) are all commonly administered neuropsychological tests found to be sensitive to brain injury. Memory, executive functions, speed of processing, and attention have been shown to be negatively affected by mild TBI roughly one year post injury (Frencham et al., 2005). These measures were administered to all study participants as part of a larger test battery.

The CVLT-II (Delis et al., 2000) consists of a 16 item word list presented five times. After each presentation, the patient repeats all of the words from the list he/she can remember. Following the fifth presentation, a second list is presented once, and the patient similarly repeats all the words from the second list he/she can remember. Following recall of the second list, the patient is asked to recall as many words as he/she can from the first list. The patient is then given semantic cues and again asked for the words on the first list. After a 20 minute delay the patient is asked to recall the words on the original list with and without semantic cues. This is followed by a recognition trial consisting of 48 words, where the patient identifies whether each word presented was from the first list or not. Ten minutes after the delayed recall and recognition, a forced

choice recognition trial is administered. During this task, the patient is asked to identify which of two words was presented on the first list. The CVLT-II has adequate split-half reliabilities (from.93 to .94) and coefficient alpha (from .82 to .83) in the normative sample and in a mixed clinical sample (Delis et al., 2000). As delayed recall has been shown to be reduced in the acute stages following a mild TBI (Carroll et al., 2004; Frencham et al., 2005), the raw score on the delayed free recall trial was used in the current analyses.

The PASAT (Levin, 1983) is a test of attention in which a string of numbers is aurally presented while the patient is asked to provide the sum of pairs of numbers so that each number presented is added to the number presented immediately before it. While there are several different forms of the PASAT, including ones where the stimuli are presented visually, the Levin version consists of four trials with 50 items per trial. The PASAT has been shown to have good test-retest reliability (rs from .73 to >.90; McCaffrey et al., 1995; Schächinger, Cox, Linder, Brody, & Keller, 2003; Sjogren, Thomsen, & Olsen, 2000). The PASAT is correlated with other measures of attention (e.g., Digit Span, TMT, Stroop; Gronwall & Wrightson, 1981; O'Donnell, MacGregor, Dabrowski, Oestreicher, & Romero, 1994; Sherman, Strauss, & Spellacy, 1997) and reaction time tasks (Deary, Langan, Hepburn, & Frier, 1991; Schächinger et al., 2003). The sum of the raw scores from Trial 1 and Trial 2 was used in the current analyses.

The TMT (Reitan, 1958) consists of two parts: part A, where the patient must connect numbers scattered across a page in order, and part B, where the patient must alternate between connecting scattered numbers and letters in order. Test retest reliability coefficients for the TMT have ranged from .46 and .44 for parts A and B, respectively

(Matarazzo, Wiens, Matarazzo, & Goldstein, 1974) to .79 and .89 (Dikmen, Heaton, Grant, & Temkin, 1999). Overall, Strauss, Sherman, and Spreen (2006) conclude the reliability is high in normal populations. The TMT has been shown to correlate moderately well with other processing speed measures, such as the Symbol Digit Modality Test and PASAT (Royan, Tombaugh, Rees, & Francis, 2004). Completion is positively related to head injury severity (Dikmen et al., 1995; Iverson, Lange, Green, & Franzen., 2002; Martin, Hoffman, & Donders, 2003). The raw time on Trails B was used in the current analyses.

Symptom Validity. Symptom validity was assessed using a variety of standardized measures of symptom validity, including the Word Memory Test (WMT; Green, 2005), Test of Memory Malingering (TOMM; Tombaugh, 1996), California Verbal Learning Test-II (CVLT-II; Delis et al., 2000) Forced Choice, Rey 15-Item Memory Test (Rey-15; Rey, 1964) recall and recognition (Boone, Salazar, Lu, Warner-Chacon, & Razani, 2002), Reliable Digit Span (RDS; Greiffenstein, Baker, & Gola, 1994), and the Minnesota Multiphasic Personality Inventory-2 (MMPI-2; Butcher et al., 1989) fake bad scale (FBS; Lees-Haley, English, & Glenn, 1991).

The WMT consists of 20 semantically related pairs of words presented orally or on a computer. The list of words is presented twice and an immediate recognition trial is administered, where the patient is presented with two words (one of which was on the original list, and one of which is new), and must identify which of two words was presented previously. After a 30 minute delay, a similar recognition trial is administered, with new distracter stimuli. Three symptom validity measures are obtained: immediate recognition, delayed recognition, and consistency (a measure of whether the patient is

consistent in the words he/she misses). A cutoff of 82.5% has been identified, with scores at or below this percentage on any of the measures considered indicative of malingering (Iverson, Green, & Gervais, 1999). The WMT has adequate internal consistency, with the correlation between the immediate and delayed recognition trials being .88, but lower test-retest reliability ($r = .43$ for the immediate recall trial and $r = .33$ for the delayed recall trial; Green, 2003). The WMT correlates well with other measures of effort, including the Computerized Assessment of Response Bias ($r > .60$), Amsterdam Short Term Memory Test ($r > .60$), and TOMM Trial 2 ($r > .68$; Green, 2007; Green, Allen, & Astner, 1997). Age, education, IQ, and specific reading disability (as long as reading level is above grade 2), which generally are related to performance on neuropsychological tests, do not affect performance on the WMT (Green & Faro, 2003), suggesting it measures effort rather than ability. Patients with moderate and severe brain injuries who perform poorly on memory measures score at or above 93% on the immediate recognition, delayed recognition, and consistency measures (Green, Lees-Haley, & Allen, 2002). Patients with moderate and severe head injuries perform better than those with mild head injuries, due to lower effort in the mild group (Green & Faro, 2003; Green, Iverson, & Allen, 1999; Green et al., 2002). Participants instructed to simulate memory deficits (Dunn, Shear, Howe, & Ris, 2003; Iverson et al., 1999; Tan et al., 2002) and individuals seeking compensation (Gervais, Russell, Green, et al., 2001; Green et al., 2002) have decreased performance on the task. Lower scores on the WMT are related to overall worse performance on neuropsychological tests, especially those of learning and memory (Gervais, Rohling, Green, & Ford, 2004; Gervais et al., 2001;

Green & Faro, 2003; Green, 2007; Green et al., 2001; Green et al., 2002), and symptom over-reporting in general (Gervais et al., 2001).

The TOMM consists of 50 line drawings presented one at a time, followed by 50 pairs of line drawings comprised of one of the original stimuli and one of the new stimuli. The patient is asked to identify the drawing that he/she saw previously. Immediately following this first trial, the original 50 items are presented again, and a similar immediate recognition trial is conducted with new distracters. Fifteen minutes following the second trial, an optional retention trial can be administered, where the patient is shown two line drawings at a time and asked to identify which one he/she saw previously. This optional trial is generally only administered if the patient scores below 45/50 on the second trial. Scores below 45 on Trial 2 (Rees, Tombaugh, Gansler, & Moczysinski, 1998) and the Retention Trial are considered indicative of malingering, with standardization data showing nearly perfect performance in normal controls and patients with aphasia, cognitive impairment or traumatic brain injury (Tombaugh, 1996). In addition, psychiatric patients, (Gierok, Dickson, & Cole, 2005), patients with depression (Ashendorf, Constantinou, &McCaffrey, 2004; Rees, Tombaugh, & Boulay, 2001), normal controls subjected to pain (Etherton, Bianchini, Greve, & Ciota, 2005), and clinically referred children (Constantinou & McCaffrey, 2003; Donders, 2005) do not differ significantly from controls or tend to fall below the cutoff score of 45. In contrast, many patients diagnosed with dementia obtain scores below 45, suggesting the TOMM should not be used with this population (Teicher & Wagner, 2004). The TOMM has been shown to be sensitive to malingering in adults (Gierok et al. 2005; Greiffenstein & Baker, 2006) and children (Donders, 2005).

The CVLT-II forced choice trial is administered ten minutes after the delayed recall and recognition trials of the CVLT-II. Patients are asked to identify which of two words was presented in the first word list. All of the new words are unrelated to both of the original words lists and many are abstract. Scoring 14 or below (out of a possible 16 points) is considered indicative of poor effort (Delis et al., 2000). Moore and Donders (2004) found the forced choice trial of the CVLT-II to be just as effective at identifying malingerers as the TOMM, though the two tests were sometimes discrepant in who they identified as malingerers.

During the Rey-15, patients are shown an array of 15 different items for 10 seconds, and after a 10 or 15 second delay are asked to reproduce this array. The patient is warned that the test is difficult because he/she must remember 15 different items; however, the items are easily grouped into three or four different categories and should therefore be quite easy to remember. A recognition trial for the Rey-15 was added by Boone and colleagues in 2002. This trial is administered 15 minutes after the recall trial and includes the 15 original stimuli, as well as 15 stimuli similar to the original stimuli. A combination score has been derived [combination score = recall correct + (recognition correct – false positives)], with a cutoff score of < 20 being shown to have variable sensitivity (ranging from 55.6% (Boone & Lu, 2007) to 71.4% (Boone et al., 2002)), but relatively strong specificity (ranging from 85.7% (Boone & Lu, 2007) to 91.7% (Boone et al., 2002)). Therefore, a combination score of <20 was considered as a positive malingering finding in the current study.

Reliable Digit Span is a measure of symptom validity embedded into the Digit Span subtest of the WAIS-IV. It is calculated by adding the longest number of digits

remembered reliably (i.e., on both trials) forward to the longest number of digits remembered reliably backward. The suggested cutoff score for RDS has ranged from < 7 (Greiffenstein et al., 1994; Greiffenstein, Gola, & Baker, 1995) to < 8 (Etherton, Bianchini, Greve, & Heinly, 2005; Inman & Berry, 2002; Meyers & Volbrecht, 1998; Strauss et al., 2002), with the lower cutoff score generally providing higher specificity. As it is of the utmost importance to maintain high specificity, the current study employed a cutoff score of <7 as indicative of malingering.

The MMPI-FBS is a 43-item scale designed to detect exaggeration in litigants. The MMPI-FBS is not completely independent of the MMPI-F, as they share five items. The MMPI-FBS has been shown to be the MMPI-2 validity scale most sensitive to malingering in forensic neuropsychological evaluations (Greiffenstein, Baker, Axelrod, Peck, & Gervais, 2004; Larrabee, 2003b; Ross, Millis, Krukowski, Putnam, & Adams, 2004); however, its specificity in psychiatric populations has been shown to be inadequate (Butcher, Arbisi, Atlis, & McNulty, 2003). The ideal cutoff score for MMPI-FBS in neurological settings has been studied by multiple parties. Greiffenstein, Baker, Gola, Donders, and Miller (2002) identified a cutoff score above 23 as discriminating litigants with atypical symptoms from nonlitigating TBI patients with 57% sensitivity and 96% specificity, while Ross et al. (2004) found a cutoff score above 20 discriminated probable malingerers from non-litigating patients with 90% sensitivity and specificity. Greve, Bianchini, Love, Brennan, and Heinly (2006) found that the MMPI-FBS scale had the highest positive predictive power at a cutoff score of 30, with a sensitivity of 40% and a specificity of 100%, and that at a cutoff score of 27 having a sensitivity of 46% and a specificity of 96%. Greiffenstein, Fox, and Lees-Haley (2007) concluded a cutoff score

of above 23 was the ideal score to identify questionable symptom validity across populations. While the findings are mixed, a cutoff score of above 23 was used in the current study.

Outcome measures. The outcome variables all assess community level outcomes. These include employment status at the time of the evaluation (recorded during a clinical interview), and participation in activities (as measured by the Participation Index of the Mayo-Portland Adaptability Inventory; MPAI; Malec, 2005).

Employment. Employment information was collected during the clinical interview. Work status at the time of the evaluation (e.g., employed full time, employed part time, full time student, part time student, none), job level (as defined by the International Standard Classification of Occupations, 2008), number of jobs held in the past year, and length of time at current job were all recorded. For the current analyses, participants were classified into three groups: unemployed (not working nor in school), employed part-time [enrolled in < 12 credit hours, working < 36 hours per week, or a combination equivalent (e.g., enrolled in 5 credit hours and working 17 hours per week)], and employed full-time [working ≥ 36 hours per week, enrolled in ≥ 12 credit hours or a combination equivalent (e.g., enrolled in 6 credit hours and working 18 hours per week)].

Participation. The Participation Index of the MPAI consists of eight items on a five-point Likert scale ranging from 0 to 4. It assesses initiation of activities, social interactions, recreational activities, basic and instrumental activities of daily living, transportation assistance needed, and employment. It has been shown to have satisfactory internal consistency, interrater reliability, and concurrent validity, as well as minimal floor and ceiling effects (Malec, 2005). If one item was unanswered on the MPAI

Participation Index, the total score was estimated based on the seven answered questions. If more than one item was unanswered, the participant was excluded from the study.

Analyses

Before running any analyses, data cleaning was conducted as outlined in Tabachnick and Fidell (2006). Each variable was checked for missing values, invalid values, as well as outliers. Data entry errors (i.e., missing and invalid values) were corrected, when possible. When any critical scores were missing (e.g., score on a symptom validity measures, employment status), the case was dropped from the relevant analyses; if however, two or fewer individual items were missing from large self report measures (e.g., PCL), the total score was estimated using mean filling procedures. Normality, linearity, and homoscedasticity were assessed and data transformations were considered. Add outliers and how many were excluded for each***

Generally, age and education are included in studies of outcome following TBI, with age negatively related to outcome (Braakman et al., 1980; Choi et al., 1983; Gomez et al., 2000; Mosenthal et al., 2004), and education positively related to outcome (Dawson et al., 2007; Ropacki & Elias, 2003). Therefore, these variables were included in the analyses as covariates. Time since injury and LOC have previously been shown to be related to PTSD and symptom report of headaches in veterans with a history of mild TBI (Hoge et al., 2008). Many of these veterans experienced multiple brain injuries, and it was often difficult for them to provide accurate dates of these multiple injuries. Rather than focusing on time since injury, time since deployment seemed to be a better measure to relate to outcome. Date of end of deployment is recorded whereas date of injury

generally is not recorded. Therefore presence or absence of LOC and time since deployment were included in the analyses as covariates.

Hypothesis 1: As has been found previously in the literature, we hypothesized that depression, posttraumatic stress symptoms, substance use, and headache interference would be inversely related to community level outcomes (i.e., employment, general community participation) while presence/absence of LOC and neuropsychological test scores would be unrelated to community level outcomes in a convenience sample of veterans about 3 years post injury. Multinomial logistic regression was performed to examine the impact of LOC, depression, posttraumatic stress symptoms, substance use, headache interference, and neuropsychological test performance (i.e., PASAT, CVLT-II delayed recall, and Trails B) on the dependent measure, employment status. Multinomial logistic regression was appropriate for this analysis because employment status is a categorical variable (not employed, employed less than full time, and employed full time).

LOC, depression, posttraumatic stress, headache interference, and substance use, were considered categorical variables, and were accounted for in the model by using indicator variables (0, or 1). No LOC, non-clinical depression level, non-clinical posttraumatic stress level, less than severe headache interference, and low risk substance use were coded as 0. Positive LOC, clinical depression level, clinical posttraumatic stress level, severe headache interference, and severe risk of substance use were coded as 1.

Multiple linear regression was performed to examine the impact of LOC, depression, posttraumatic stress symptoms, substance use, headache interference, and neuropsychological test performance on general community participation.

Hypothesis 2: The number of symptom validity tests failed would be inversely related to community level outcomes (i.e., employment and general community participation), even when taking into account presence/absence of LOC, depression, posttraumatic stress symptoms, substance use, headache interference, and neuropsychological test scores in the same sample. Multinomial logistic regression was performed to examine the impact of LOC, depression, posttraumatic stress symptoms, substance use, headache interference, neuropsychological test performance (i.e., PASAT, CVLT-II delayed recall, and Trails B), number of symptom validity tests failed, and service connection status on the dependent measure, employment status. A multiple linear regression was conducted with number of symptom validity measures failed, LOC, psychological and behavioral factors, and service connection status as the independent variables and MPAI Participation Index score as the dependent variable. We were particularly interested in the relationship between symptom validity and community level outcome and we suspected service connection status might be highly correlated with number of symptom validity tests failed (thus creating a high degree of multicollinearity between predictor variables). Therefore, we repeated the above analysis, excluding service connection status, to evaluate the difference in the percent variance in the percent variance in community level outcome explained by the symptom validity test results.

Hypothesis 3: The relation between depression, posttraumatic stress symptoms, substance use, headache interference, and neuropsychological test scores and community level outcomes (i.e., employment and general community participation) would be dependent upon symptom validity performance. Specifically, in veterans who have no indication of symptom validity issues, community level outcome would

be inversely related to anxiety, depression, posttraumatic stress symptoms, substance use, headache interference, and presence/absence of LOC, and positively related to neuropsychological test scores. The strength of these relations would be attenuated in veterans who fail any of the symptom validity measures. To evaluate the interaction between symptom validity test failure and LOC, psychological and behavioral factors, service connection status, and neuropsychological test performance on employment, a multinomial logistic regression was performed. To evaluate the interaction between symptom validity test failure and LOC, psychological and behavioral factors, service connection status, and neuropsychological test performance on general community participation, an ANOVA was performed.

Results

Participants

Of the initial 117 veterans considered for inclusion in this study, 10 were excluded due to incomplete injury data and/or incomplete demographic data and 3 were excluded due to indicators of severe TBI, leaving 104 potential participants for the analyses. The excluded participants did not differ from the included participants in terms of age, education, ethnicity, branch of service, time since deployment. The excluded participants differed in terms of presence of LOC (χ^2 (1, N = 109) = 4.61, p = .032). Eight of the 13 excluded participants were missing data on the presence/absence of LOC and the remaining 5 all had positive LOC. Demographics, military service, and injury severity characteristics of the final sample are found in Table 1.

Demographics and Injury Characteristics

One-way ANOVAs and chi squared tests were conducted to examine possible differences in time since deployment, age, education, race, branch of service, and LOC between participants who passed vs. failed the WMT. Time since deployment ($F(1, 97) = .668$, $p = .416$), age $F(1, 97) = 3.23$, $p = .071$), education $F(1, 97) = .693$, $p = .407$), race ($\chi^2(3, N = 98) = .351$, $p = .950$), branch of service (χ^2 $(4, N = 99) = 2.08$, $p = .721$), and the presence of LOC (χ^2 $(1, N = 99) = .487$, $p = .485$) did not significantly differ between the groups.

Hypothesis 1: Depression, posttraumatic stress symptoms, substance use, and headache interference would be inversely related to community level outcomes while presence/absence of LOC and neuropsychological test scores would be unrelated to community level outcomes.

In order to determine the relationship between demographic variables, injury factors, psychological symptoms, and neuropsychological test performance and the MPAI Participation Index total score, a multiple linear regression was conducted. Years of education, age, time since deployment, and LOC were entered into the first block. PCL score greater than or equal to 50 vs. less than 50), MMPI-II RC2 t score (greater than or equal to 66 vs. less than 66), ASSIST score (greater than18 on the alcohol scale and/or greater than 14 on any other scale vs. less than or equal to 18 on the alcohol scale and/or less than or equal to 14 on any other scale), HIT-6 score (greater than or equal to 60 vs. less than 60), CVLT-II delayed recall raw score, PASAT trial 2 raw score, and Trail Making Test B raw time were entered into the second block. MPAI Participation Index total score was the dependent variable. For the predictor variables, all variance inflation factor (VIF) values were less than or equal to 1.6 and all tolerance values were greater

than .66. The obtained VIF and tolerance values were significantly below the recommended values for variable exclusion and suggest the absence of high multicollinearity among predictors in the model (Menard, 1995; Myers, 1990). The first model was not significant (R^2 = .066, F(4, 92) = 1.61, p = .177). In this model, neither age (β = .134, p = .241), education (β = -.139, p = .193), months since deployment (β = .169, p = .122), nor LOC (β = .015, p = .885) were significant predictors of MPAI Participation Index total. The second model was significant and explained an additional 37% of the variance in community level outcome (R^2 = .435, F(11, 85) = 5.96, p < .001, R^2 change = .370, p <.001). PTSD (β = .304, p = .003), depression (β = .226, p = .022), and headache interference (β = .267, p = .003) significantly predicted MPAI Participation Index total with increased symptomatology in each of these areas related to worse MPAI score. None of the cognitive variables were significant (all ps >.05). For the complete results with β and p values, please see Table 2.

In order to determine the relationship between demographic variables, injury factors, psychological symptoms, and neuropsychological test performance and employment status, a multinomial logistic regression was conducted. Years of education, age, time since deployment, LOC, PCL score, MMPI-II RC2 t score, ASSIST score, HIT-6 score, CVLT-II delayed recall raw score, PASAT trial 2 raw score, and Trail Making Test B raw time were independent variables, and employment status (none, part-time, full-time) was the dependent variable.

The omnibus test for the model was not statistically significant, χ^2 (22, N = 99) = 26.9, p = .214. Nagelkerke's R^2 of .274 indicated a slight relationship between prediction

and grouping. Prediction success overall was 57.6% (29.3% for unemployed, 8.1% for employed part-time, and 62.6% for employed full-time). Because the overall model was not significant, the contributions of the individual variables were not determined, but can be found in Table 3.

Hypothesis 2: The number of symptom validity tests failed would be inversely related to community level outcomes, even when taking into account the variables included in Hypothesis 1.

In order to investigate this hypothesis, a multiple linear regression was conducted. Years of education, age, time since deployment, and LOC were entered into the first block. PCL score greater than or equal to 50 vs. less than 50), MMPI-II RC2 t score (greater than or equal to 66 vs. less than 66), ASSIST score (greater than18 on the alcohol scale and/or greater than 14 on any other scale vs. less than or equal to 18 on the alcohol scale and/or less than or equal to 14 on any other scale), HIT-6 score (greater than or equal to 60 vs. less than 60), CVLT-II delayed recall raw score, PASAT trial 2 raw score, Trail Making Test B raw time, number of symptom validity tests failed, and service connection status (applying for an increase or appealing a rejection vs. not) were entered into the second block. MPAI Participation Index total score was the dependent variable. For the predictor variables, all VIF values were less than or equal to 2.7 and all tolerance values were greater than .38, suggesting the absence of high multicollinearity among predictors in the model (Menard, 1995; Myers, 1990). Similar to hypothesis 1, the first model was not significant ($R^2 = .065$, $F(4, 86) = 1.49$, $p = .213$) and age, education, days since deployment, and LOC were not significant predictors of MPAI Participation Index. The second model was significant and explained an additional 42% of the variance in

community level outcome (R^2 = .486, F(13, 77) = 7.01, p < .001; R^2 change = .421, p < .001). Headache interference (β = .261, p = .004), PTSD (β = .224, p = .041), and total number of symptom validity measures failed (β = .309, p = .022) significantly predicted MPAI Participation Index total, with increased symptomatology on each of these measures related to worse MPAI score. None of the cognitive variables were significant (all ps >.05). Of note, when adding service connection status and number of symptom validity tests failed to the second block, the percent variance explained by the second block increased by only 3% relative to the second block in hypothesis 1; however, this is likely due to the fact that the beta weights for PTSD, MMPI-II RC2, and Trails B all decreased when service connection status and number of symptom validity tests failed were added to the second block. For the complete results with β and p values, please see Table 4.

The analysis was repeated without service connection status. For the predictor variables, all VIF values were less than or equal to 2.7 and all tolerance values were greater than .37, suggesting the absence of high multicollinearity among predictors in the model (Menard, 1995; Myers, 1990). The first model was not significant (R^2 = .059, F(4, 88) = 1.37, p = .250) and age, education, days since deployment, and LOC were not significant predictors of MPAI Participation Index. The second model was significant and explained an additional 39% of the variance in community level outcome (R^2 = .448, F(12, 80) = 5.41, p < .001; R^2 change = .389, p < .001). Headache interference (β = .241, p = .008) and PTSD (β = .236, p = .032) significantly predicted MPAI Participation Index total, with increased symptomatology on each of these measures related to worse MPAI

score. None of the cognitive variables were significant (all ps >.05). For the complete results with β and p values, please see Table 5.

In order to determine the relationship between demographic variables, injury factors, psychological symptoms, neuropsychological test performance, and symptom validity performance with employment status, a multinomial logistic regression was conducted. Years of education, age, time since deployment, LOC, PCL score, MMPI-II RC2 t score, ASSIST score, HIT-6 score, CVLT-II delayed recall raw score, PASAT trial 2 raw score, Trail Making Test B raw time, number of symptom validity tests failed, and service connection status (applying for an increase or appealing a rejection vs. not) were independent variables, and employment status (none, part-time, full-time) was the dependent variable.

The omnibus test for the model was not statistically significant, χ^2 (26, N = 91) = 31.78, p = .200. Nagelkerke's R^2 of .341 indicated a slight relationship between prediction and grouping. Prediction success overall was 60.4% (22.0% for unemployed, 9.9% for employed part-time, and 68.1% for employed full-time). Because the overall model was not significant, the contributions of the individual variables were not determined, but can be found in Table 6.

The model was repeated without service connection status. The omnibus test for this model was also not statistically significant, χ^2 (24, N = 93) = 29.17, p = .214. Nagelkerke's R^2 of .311 indicated a slight relationship between prediction and grouping. Prediction success overall was 61.3% (25.8% for unemployed, 8.6% for employed part-time, and 65.6% for employed full-time). Because the overall model was not significant,

the contributions of the individual variables were not determined, but can be found in Table 7.

Hypothesis 3: The relation between psychological symptoms and neuropsychological test scores and community level outcomes would be dependent upon symptom validity performance. Specifically, in veterans who pass the Word Memory Test, community level outcome would be inversely related to PTSD, and presence/absence of LOC, and positively related to CVLT-II delayed recall performance. The strength of these relations would be attenuated in veterans who fail the WMT.

In order to investigate this hypothesis, an ANOVA was conducted. MPAI Participation Index total score was the dependent variable. The main effects of years of education, age, time since deployment, LOC, PCL score, CVLT-II delayed recall raw score, WMT performance, and service connection status, as well as the interaction effects of WMT performance*PCL score and WMT performance*CVLT-II delayed recall raw score were included in the model. The model was significant, explaining 37% of the variance in community level outcome ($R^2 = .396$, $F(10, 84) = 5.51$, $p < .001$). In this model, CVLT-II delayed recall ($F(1, 84) = 7.39$, $p = .008$, $\eta_p^2 = .081$), PCL ($F(1, 84) = 5.84$, $p = .018$, $\eta_p^2 = .065$), WMT ($F(1, 84) = 5.47$, $p = .022$, $\eta_p^2 = .061$), and CVLT*WMT failure ($F(1, 84) = 7.10$, $p = .009$, $\eta_p^2 = .078$) were significant. PCL scores >49 were related to lower MPAI scores. For participants who failed the WMT, the average score on the CVLT-II delayed recall was 7.58 (SD = 3.72) and the average score on the MPAI participation index was 13.4 (SD = 6.18). For participants who passed the WMT, the average score on the CVLT-II delayed recall was 13.0 (SD = 2.67) and the

average score on the MPAI participation index was 9.45 (SD = 6.39). In participants who failed the WMT, level of community functioning on the MPAI was not strongly related to CVLT-II delayed recall performance. Participants who passed the WMT had better MPAI scores overall, as well as better performance on the CVLT-II delayed recall, with none of these participants scoring below 6 on the CVLT-II delayed recall. See Figure 1. For complete results, please see Table 8.

The model was rerun without service connection status. The model was significant, explaining 39% of the variance in community level outcome ($R^2 = .386$, $F(9, 87) = 6.09$, $p < .001$). In this model, CVLT-II delayed recall ($F(1, 87) = 7.47$, $p = .008$, $\eta_p^2 = .079$), PCL ($F(1, 87) = 5.54$, $p = .021$, $\eta_p^2 = .060$), WMT ($F(1, 87) = 5.51$, $p = .021$, $\eta_p^2 = .060$), and CVLT*WMT failure ($F(1, 87) = 7.49$, $p = .008$, $\eta_p^2 = .079$) were significant. For complete results, please see Table 9.

In order to investigate the relationship between age, education, time since deployment, LOC, PTSD, and CVLT-II delayed recall performance and employment status, a multinomial logistic regression was conducted. Employment status (none, part-time, full-time) was the dependent variable. The main effects of years of education, age, time since deployment, LOC, PCL score, CVLT-II delayed recall raw score, and WMT performance, as well as the interaction effects of WMT performance*PCL score and WMT performance*CVLT-II delayed recall raw score were included in the model.

The omnibus test for the model was not statistically significant, $\chi^2 (20, N = 96) = 25.1$, $p = .197$. Nagelkerke's R^2 of .266 indicated a slight relationship between prediction and grouping. Prediction success overall was 55.2% (27.1% for unemployed, 6.3% for employed part-time, and 66.7% for employed full-time). Because the overall model was

not significant, the contributions of the individual variables were not determined, but can be found in Table 10.

The model was repeated without service connection status. The omnibus test for this model was not statistically significant, χ^2 (18, N = 98) = 24.15, p = .150. Nagelkerke's R^2 of .252 indicated a slight relationship between prediction and grouping. Prediction success overall was 58.2% (42.2% for unemployed, 5.1% for employed part-time, and 69.4% for employed full-time). Because the overall model was not significant, the contributions of the individual variables were not determined, but can be found in Table 11.

Discussion

This study investigated differences in community level outcome based on injury characteristics, psychological symptoms, and neuropsychological performance in OEF/OIF veterans, and in particular, how symptom validity test failure moderated these relationships. Veterans who passed the WMT did not differ from veterans who failed the WMT in terms of age, education, race, branch of service, time since deployment, or LOC. Overall, headache interference, PTSD, and symptom validity test failure were all related to worse community level outcome in our convenience sample of veterans reporting to the VA for neuropsychological testing an average of 45.5 months post deployment. Interestingly, while psychological variables and symptom validity test failure were related to overall community level outcome, there was no relationship between these variables and employment status.

The initial model, investigating the relationship between demographics, injury characteristics, psychological status, cognitive performance and psychological status with

community level outcome, psychological status and cognitive performance explained an additional 37% of the variance in community level outcome over and above demographics and injury characteristics, with increased PTSD, depression, and headache interference significantly related to reduced level of community participation. When number of symptom validity tests failed and service connection status were entered into the second block of the model, the second block (including psychological status and cognitive performance) explained 42% of the variance in community level outcome over and above that explained by demographics and injury characteristics, with PTSD, headache interference, and total number of symptom validity tests failed significantly related to level of community participation. When simplifying the model to include only one cognitive (delayed recall) and one psychological (PTSD) variable, and to investigate the interaction between WMT failure and each of these variables, this model explained 40% of the variance in level of community participation, with delayed recall, PTSD, WMT failure, and the interaction between delayed recall and WMT failure significantly related to level of community participation. PTSD was related to lower level of community participation. Participants who failed the WMT tended to have worse delayed recall than participants who passed the WMT. Participants who passed the WMT had better community level participation overall, and none of these participants scored below 6 on the CVLT-II delayed recall.

When evaluating the relationship between demographics, injury characteristics, cognitive performance and psychological status and employment status, the omnibus test was non-significant, precluding examination of the individual components of the model. The omnibus test remained non-significant when adding symptom validity and service

connection status into the model and when eliminating two cognitive and three psychological variables from the model.

The current study found that symptom validity, PTSD, and headache interference all relate to general community participation. Additionally, as has been found previously (Drag et al., 2012; Hanlon et al., 1999, Hinton-Bayre & Geffen, 2002; Lippa et al., 2010), the occurrence of LOC was not significantly related to outcome. These findings are consistent with previous research as many recent studies have also shown that PTSD accounts for more of the variance in mild TBI outcome than injury variables (Lippa et al., 2010; Polusny et al., 2011; Wilk, Herrell, Wynn, Riviere, & Hoge, 2012) and build on Hoge and colleagues' (2008) findings that in veterans with and without history of mild TBI, headache interference tends to be related to outcome, even after accounting for psychological issues such as depression and PTSD. Our study supports the idea that comorbid factors, such as PTSD and pain play a larger role in community level outcome than the distal mild brain injury. It seems that clinicians can best serve veterans with a history of mild TBI by focusing on interventions for these comorbid issues in order to maximize their overall outcome. Indeed, there are many evidence based interventions for PTSD and headache, as well as options for combined treatment (see Otis, McGlinchey, Vasterling, & Kerns (2011) for a review).

While a fair number of studies have investigated how psychological and cognitive factors affect impairment and participation following mild TBI, to date, no studies have investigated the relationship between failing symptom validity measures and their generalizability to community level outcomes. When neuropsychologists employ symptom validity measures, it is typically to determine if the neuropsychological test

results validly reflect the individuals' true cognitive ability. The field of neuropsychology has not yet questioned whether these symptom validity tests themselves can be useful above and beyond determining the validity of neuropsychological test results. The current study found a relationship between effort during neuropsychological testing and functioning in everyday life as veterans who failed symptom validity measures were more likely to report problems in their everyday lives. This suggests patients may be adopting the 'sick role' both inside and outside the hospital; however, this relationship does not extend to employment status, indicating that, in veterans with history of mild TBI, this motivational component does not affect the likelihood of being employed, but rather how much one engages in areas of life outside of work. Knowledge about this relationship would likely serve as valuable information for developing interventions following mild TBI.

One of the main goals behind Slick, Sherman and Iverson's (1999) proposed criteria for diagnosing malingering was to encourage clinicians to not shy away from specifically assessing for malingering and documenting malingering or indications of possible malingering in assessment reports. Future studies are needed to identify correlates of poor symptom validity, and specifically, how symptom validity relates to community level outcomes. With improved understanding of this relationship, the concept of malingering, as well as poor effort, will continue to be both destygmatized and demystied, which could not only lead practitioners to feel more comfortable discussing symptom validity test results, but also inform both prevention and treatment of symptom validity issues, as Slick and colleagues (1999) urge.

Interestingly, 75% of Veterans failed at least one measure of symptom validity (out of six symptom validity measures), with 60% of veterans failing the WMT, the measure that appeared to be the most sensitive to suboptimal effort in the current study. Financial compensation has been shown to play a large role in probable symptom exaggeration (Binder & Rohling, 1996; Cook, 1972; Miller, 1961; Paniak et al., 2002; Reynolds, Paniak, Toller-Lobe, & Nagy, 2003). Rates of symptom validity failure in veterans with mild TBI reporting for neuropsychological evaluation have been as high as 58% in previously published studies (Armistead-Jehle, 2010). It seems that this would likely explained by the strong financial incentives available to patients within the VA health care system, as compensation may be increased if residual cognitive deficits secondary to a history of brain injury are demonstrated; however in our study, service connection status did not strongly alter the results. A post-hoc analysis to investigate the relation between service connection status and symptom validity test failure revealed that service connection status was not significantly correlated with WMT failure or total number of SVTs failed.

Of course, along with financial incentive, there are likely many other factors that affect both symptom validity performance and community level outcome. It seems especially likely that in the veteran population, physical issues (e.g., severity of brain damage, history of past injuries), psychological issues (e.g., PTSD, anxiety, depression) and environmental factors (e.g., chaotic living environment, income, social support), may play a role both in symptom validity performance and in community level outcome years following a mild TBI. It is important that all contributing factors be considered when predicting outcome (Shames, Treger, Ring, & Giaquinto, 2007) as multiple stressors

combine with each other and with premorbid psychological and medical factors to result in increased disability (Evered, Ruff, Baldo, & Isomura, 2003). It is our hope that further research will lead to useful information about how those who fail symptom validity measures differ from those who pass symptom validity measures with regard to psychological, behavioral, environmental, and cognitive characteristics. Following, or perhaps, in conjunction with an accurate description of these populations, interventions specific to those who exhibit poor symptom validity can be developed to help them form and accomplish meaningful life goals. Perhaps these will involve shifting the focus from how people can be compensated for their past injuries to how people view themselves, what they hope to accomplish with their lives, and the most effective way to accomplish these goals.

The current study is not without limitations. This study relied on self-report to diagnose a history of mild TBI, self report measures of psychological symptoms, as well as self-report of current community level participation. Problems with self-report include differences in willingness to admit problems, symptom exaggeration, and the fallibility of memory (Loftus, Levidow, & Duensing, 2002). Van Dyke et al. (2010) have called into question the reliability of self report information pertaining to injury characteristics and symptom report in the population of returning veterans. Not only does the reliance on self report call into question the reliability of the data, the reliance on a similar method of data collection for many of the predictor variables and the outcome variable in this study creates the potential for inflated correlations between variables due to method variance (Campbell & Fiske, 1959). Despite this, patient self report, as facilitated by clinical interview, is currently the “gold-standard” for the historical diagnosis of a brain injury

(Corrigan & Bogner, 2007, p. 316). An additional limitation of this study is that the retrospective design of the study precludes any statements indicating causality between variables. The current study attempted to avoid inadequate power by eliminating variables from the final analyses; however, it is quite possible that true significant interaction effects were missed due to lack of power. Future studies with large samples will be necessary to evaluate community level outcome in veterans from a cumulative disadvantage perspective. Additionally, while there was not a significant association between presence of LOC and community level outcome, the lack of a control group without a history of mild TBI precludes any conclusions about the relation between presence versus absence of history of mild TBI and community level outcome. Nonetheless, the current results support the ideal of addressing physical and psychiatric comorbidities common in early in the course of treatment before focusing on the history of mild TBI (Department of Veterans Affairs and Department of Defense, 2009).

The results of this study indicate that PTSD, headaches, and symptom validity test failure are all related to community level outcome in veterans with remote history of mild TBI, while LOC, time since deployment, and cognitive abilities are largely unrelated. This study highlights the importance of assessing symptom validity in clinical cases of mild TBI and in clinical research studies involving mild TBI patients. It also supports the treatment strategy of addressing current comorbid conditions, such as PTSD and headaches, rather than focusing on the remote history of mild TBI.

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Table 1. Demographics of the Study Population

	Passed WMT (n = 39)	Failed WMT (n = 42)	Overall (n = 104)
Demographic Information			
Age, *mean* (SD)	30.1 (7.4)	33.1 (8.1)	31.8 (7.9)
Education, *mean* (SD)	12.9 (1.4)	13.2 (1.8)	13.0 (1.6)
Males, No. (%)	39 (100)	56 (93.3)	100 (96.2)
Employment Status			
Unemployed, No. (%)	15 (39.5)	18 (30.0)	35 (34.0)
Employed Part-time, No. (%)	7 (18.4)	9 (15.0)	17 (16.5)
Employed Full-time, No. (%)	16 (42.1)	33 (55.0)	49 (49.5)
Ethnicity			
African American, No. (%)	4 (10.3)	8 (13.3)	13 (12.6)
Caucasian, No. (%)	25 (64.1)	37 (62.7)	65 (63.1)
Hispanic, No. (%)	9 (23.1)	12 (20.0)	21 (20.4)
Multiracial, No. (%)	0 (0.0)	1 (1.7)	1 (1.0)
Other, No. (%)	1 (2.6)	1 (1.7)	3 (2.9)
Military Information			
Air Force, No. (%)	1 (2.6)	3 (5.0)	4 (3.8)
Army, No. (%)	26 (66.7)	44 (70.0)	72 (69.2)
Marines, No. (%)	9 (23.1)	8 (13.3)	18 (17.3)
National Guard, No. (%)	1 (2.4)	2 (3.3)	3 (2.9)
Navy, No. (%)	2 (5.1)	5 (8.3)	7 (6.7)
Injury Characteristics			
Positive LOC, No. (%)	18 (46.2)	32 (53.3)	53 (51.0)
Months Since Deployment, *mean* (SD)	41.5 (26.1)	46.3 (29.4)	44.1 (28.5)

Note: Age and education are in years.

Table 2. Multiple Linear Regression for Hypothesis 1

Model		Beta	Sig.
1	(Constant)		.020
	Age	.134	.241
	Education	-.139	.193
	Time since deployment	.169	.122
	Loss of consciousness	.015	.885
2	(Constant)		.843
	Age	.051	.605
	Education	-.012	.895
	Time since deployment	.050	.610
	Loss of consciousness	.048	.585
	PCL	.304	.003
	MMPI RC2	.226	.022
	HIT-6	.267	.003
	ASSIST	.100	.253
	CVLT-II delayed recall	.013	.887
	Trails B time	.134	.172
	PASAT Trial 2 raw score	.034	.720

Table 3. Multinomial Logistic Regression Results for Hypothesis 1

							95% Confidence Interval for Exp(B)	
		B	Std. Error	Wald	Sig.	Exp(B)	Lower Bound	Upper Bound
Unemployed vs. Part-time employment	Intercept	-5.72	3.57	2.56	0.11			
	Age	0.00	0.05	0.01	0.92	1.00	0.90	1.10
	Education	0.43	0.25	2.94	0.09	1.54	0.94	2.53
	Time since deployment	0.00	0.00	0.22	0.64	1.00	1.00	1.00
	LOC	-0.14	0.71	0.04	0.84	0.87	0.22	3.47
	PCL	-1.73	0.87	4.01	0.05	0.18	0.03	0.96
	MMPI RC2	0.91	0.82	1.23	0.27	2.49	0.50	12.44
	HIT-6	0.30	0.74	0.16	0.68	1.35	0.32	5.78
	ASSIST	-0.47	0.90	0.27	0.60	0.63	0.11	3.62
	CVLT-II DR	0.08	0.09	0.82	0.36	1.08	0.91	1.29
	Trails B time	0.00	0.01	0.02	0.88	1.00	0.98	1.03
	PASAT Trial 2	-0.01	0.02	0.07	0.80	0.99	0.95	1.04
Unemployed vs. Full-time employment	Intercept	-6.06	2.87	4.44	0.04			
	Age	-0.04	0.04	0.99	0.32	0.96	0.89	1.04
	Education	0.45	0.20	5.40	0.02	1.57	1.07	2.31
	Time since deployment	0.00	0.00	0.48	0.49	1.00	1.00	1.00
	LOC	0.69	0.51	1.84	0.17	2.00	0.73	5.46
	PCL	-0.25	0.70	0.12	0.72	0.78	0.20	3.06
	MMPI RC2	0.02	0.61	0.00	0.98	1.02	0.31	3.35
	HIT-6	-0.66	0.56	1.37	0.24	0.52	0.17	1.56
	ASSIST	0.01	0.65	0.00	0.99	1.01	0.28	3.60
	CVLT-II DR	-0.02	0.07	0.12	0.73	0.98	0.86	1.11
	Trails B time	0.02	0.01	3.69	0.05	1.02	1.00	1.04
	PASAT Trial 2 raw score	0.01	0.02	0.38	0.54	1.01	0.98	1.04

Table 4. Multiple Linear Regression for Hypothesis 2 with Service Connection Status

Model		Beta	Sig.
1	(Constant)		.013
	Age	.106	.374
	Education	-.143	.199
	Time since deployment	.190	.096
	Loss of consciousness	-.020	.851
2	(Constant)		.299
	Age	.098	.331
	Education	-.154	.090
	Time since deployment	.068	.473
	Loss of consciousness	.040	.647
	PCL	.224	.041
	MMPI RC2	.180	.071
	HIT-6	.261	.004
	ASSIST	.140	.114
	CVLT-II delayed recall	.147	.200
	Trails B time	.045	.633
	PASAT Trial 2	-.007	.938
	Total SVTs failed	.309	.022
	Change in SCS	-.063	.489

Table 5. Multiple Linear Regression for Hypothesis 2 without Service Connection Status

	Model	Beta	Sig.
1	(Constant)		.025
	Age	.115	.329
	Education	-.122	.267
	Time since deployment	.173	.126
	Loss of consciousness	.001	.993
2	(Constant)		.570
	Age	.121	.231
	Education	-.117	.201
	Time since deployment	.018	.852
	Loss of consciousness	.060	.496
	PCL	.236	.032
	MMPI RC2	.191	.061
	HIT-6	.241	.008
	ASSIST	.085	.342
	CVLT-II delayed recall	.137	.240
	Trails B time	.054	.573
	PASAT Trial 2	.008	.930
	Total SVTs failed	.253	.065

Table 6. Multinomial Logisitic Regression for Hypothesis 2 with Service Connection Status

							95% CI	
		B	Std. Error	Wald	Sig.	Exp (B)	Lower Bound	Upper Bound
Unemployed vs. Part-time employment	Intercept	-5.13	4.04	1.61	0.20			
	Age	0.02	0.06	0.11	0.74	1.02	0.91	1.14
	Education	0.20	0.27	0.55	0.46	1.23	0.72	2.10
	Time since deployment	0.00	0.00	0.34	0.56	1.00	1.00	1.00
	LOC	-0.19	0.82	0.05	0.82	0.83	0.17	4.12
	PCL	-3.27	1.17	7.79	0.01	0.04	0.00	0.38
	MMPI RC2	1.16	0.96	1.45	0.23	3.19	0.48	21.09
	HIT-6	0.61	0.84	0.53	0.47	1.84	0.36	9.46
	ASSIST	0.21	1.05	0.04	0.84	1.24	0.16	9.70
	CVLT-II DR	0.19	0.13	2.24	0.13	1.21	0.94	1.55
	Trails B	0.00	0.01	0.06	0.81	1.00	0.97	1.03
	PASAT Trial 2	0.00	0.02	0.01	0.92	1.00	0.96	1.05
	Total SVTs failed	0.79	0.42	3.57	0.06	2.19	0.97	4.96
	Change in SCS	-0.29	0.84	0.12	0.73	0.74	0.14	3.88
Unemployed vs. Full-time employment	Intercept	-6.04	2.98	4.11	0.04			
	Age	-0.03	0.04	0.71	0.40	0.97	0.89	1.05
	Education	0.43	0.20	4.74	0.03	1.53	1.04	2.25
	Time since deployment	0.00	0.00	0.03	0.86	1.00	1.00	1.00
	LOC	0.62	0.56	1.25	0.26	1.86	0.63	5.54
	PCL	-0.76	0.84	0.83	0.36	0.47	0.09	2.42
	MMPI RC2	0.11	0.65	0.03	0.87	1.12	0.31	4.02
	HIT-6	-0.67	0.62	1.17	0.28	0.51	0.15	1.72
	ASSIST	0.00	0.78	0.00	1.00	1.00	0.22	4.57
	CVLT-II DR	0.00	0.09	0.00	0.99	1.00	0.84	1.19
	Trails B	0.01	0.01	2.53	0.11	1.01	1.00	1.03
	PASAT Trial 2	0.00	0.02	0.06	0.81	1.00	0.97	1.04
	Total SVTs failed	0.21	0.29	0.54	0.46	1.24	0.70	2.18
	Change in SCS	0.92	0.58	2.55	0.11	2.52	0.81	7.83

Table 7. Multinomial Logistic Regression Results for Hypothesis 2 without Service Connection Status

							95% Confidence Interval for Exp(B)	
		B	Std. Error	Wald	Sig.	Exp (B)	Lower Bound	Upper Bound
Unemployed vs. Part-time employment	Intercept	-6.44	3.98	2.62	0.11			
	Age	0.02	0.05	0.17	0.68	1.02	0.92	1.14
	Education	0.31	0.28	1.29	0.26	1.37	0.80	2.35
	Time since deployment	0.00	0.00	0.62	0.43	1.00	1.00	1.00
	LOC	-0.22	0.78	0.08	0.78	0.80	0.17	3.71
	PCL	-2.86	1.09	6.90	0.01	0.06	0.01	0.48
	MMPI RC2	1.02	0.91	1.26	0.26	2.79	0.47	16.67
	HIT-6	0.45	0.82	0.30	0.58	1.57	0.32	7.76
	ASSIST	-0.18	0.99	0.03	0.86	0.84	0.12	5.88
	CVLT-II delayed recall	0.18	0.12	2.18	0.14	1.20	0.94	1.53
	Trails B time	0.00	0.01	0.08	0.77	1.00	0.97	1.02
	PASAT Trial 2	0.00	0.02	0.00	0.97	1.00	0.96	1.05
	Total SVTs failed	0.71	0.40	3.05	0.08	2.03	0.92	4.48
Unemployed vs. Full-time employment	Intercept	-5.99	2.94	4.15	0.04			
	Age	-0.04	0.04	1.07	0.30	0.96	0.89	1.04
	Education	0.45	0.20	4.81	0.03	1.56	1.05	2.32
	Time since deployment	0.00	0.00	0.22	0.64	1.00	1.00	1.00
	LOC	0.85	0.54	2.51	0.11	2.34	0.82	6.72
	PCL	-0.28	0.76	0.13	0.72	0.76	0.17	3.38
	MMPI RC2	0.07	0.63	0.01	0.91	1.08	0.31	3.73
	HIT-6	-0.76	0.60	1.61	0.20	0.47	0.15	1.51
	ASSIST	-0.08	0.72	0.01	0.91	0.92	0.23	3.75
	CVLT-II DR	-0.01	0.09	0.01	0.93	0.99	0.84	1.17
	Trails B time	0.01	0.01	2.65	0.10	1.01	1.00	1.03
	PASAT Trial 2	0.00	0.02	0.06	0.80	1.00	0.97	1.04
	Total SVTs failed	0.19	0.28	0.46	0.50	1.21	0.69	2.12

Table 8. ANOVA for Hypothesis 3 with Service Connection Status

Source	F	Sig.	Partial Eta Squared
Corrected Model	5.51	0.00	0.40
Intercept	0.54	0.46	0.01
Age	1.19	0.28	0.01
Education	1.04	0.31	0.01
Time since deployment	1.90	0.17	0.02
Loss of consciousness	0.29	0.59	0.00
PCL	5.84	0.02	0.07
CVLT-II Delayed Recall	7.40	0.01	0.08
WMT	5.47	0.02	0.06
Change in SCS	0.42	0.52	0.00
WMT*PCL	3.16	0.08	0.04
WMT*CVLT-II	7.10	0.01	0.08

Table 9. ANOVA for Hypothesis 3 without Service Connection Status

Source	F	Sig.	Partial Eta Squared
Corrected Model	6.09	0.00	0.39
Intercept	1.03	0.31	0.01
Age	1.59	0.21	0.02
Education	0.50	0.48	0.01
Time since deployment	0.97	0.33	0.01
Loss of consciousness	0.30	0.58	0.00
PCL	5.54	0.02	0.06
CVLT-II Delayed Recall	7.47	0.01	0.08
WMT	5.51	0.02	0.06
WMT*PCL	3.32	0.07	0.04
WMT*CVLT-II	7.49	0.01	0.08

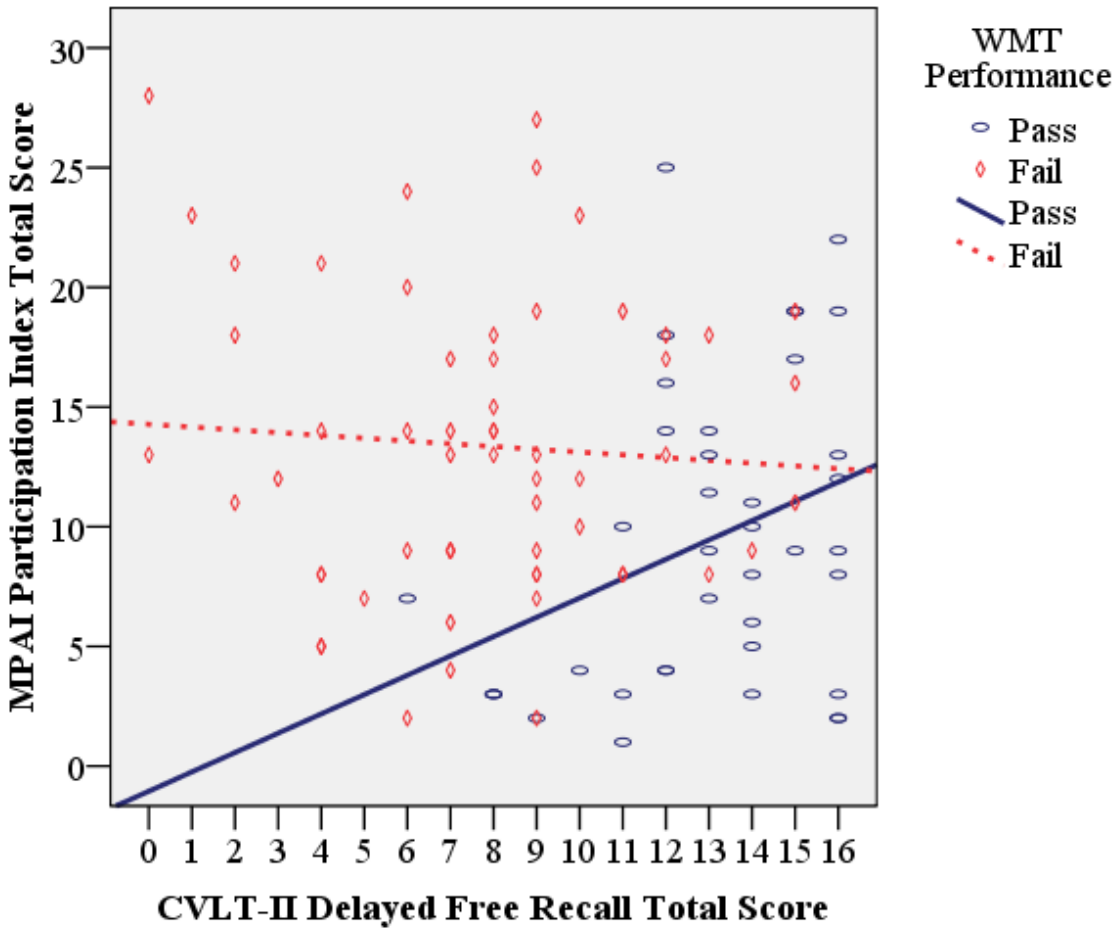
Table 10. Multinomial Logistic Regression Results for Hypothesis 3 with Service Connection Status

							95% Confidence Interval for Exp(B)	
		B	Std. Error	Wald	Sig.	Exp(B)	Lower Bound	Upper Bound
Unemployed vs. Part-time employment	Intercept	5.17	3.15	2.70	0.10			
	Age	0.04	0.04	1.33	0.25	1.04	0.97	1.12
	Education	-0.32	0.17	3.48	0.06	0.72	0.51	1.02
	Time since deployment	0.00	0.00	0.30	0.58	1.00	1.00	1.00
	LOC	-0.52	0.52	1.01	0.32	0.60	0.22	1.64
	PCL	1.03	0.89	1.36	0.24	2.81	0.50	15.9
	CVLT-II DR	-0.18	0.16	1.21	0.27	0.84	0.61	1.15
	WMT	-2.47	2.27	1.19	0.28	0.08	0.00	7.20
	Change in SCS	-0.68	0.54	1.61	0.20	0.51	0.18	1.45
	WMTPCL	-0.57	1.26	0.20	0.65	0.57	0.05	6.67
	WMT* CVLT-II	0.17	0.18	0.87	0.35	1.19	0.83	1.70
Unemployed vs. Full-time employment	Intercept	-4.80	4.69	1.05	0.31			
	Age	0.05	0.05	0.86	0.35	1.05	0.95	1.16
	Education	-0.15	0.22	0.49	0.48	0.86	0.56	1.31
	Time since deployment	0.00	0.00	0.26	0.61	1.00	1.00	1.00
	LOC	-0.82	0.66	1.53	0.22	0.44	0.12	1.62
	PCL	-2.62	1.35	3.75	0.05	0.07	0.01	1.03
	CVLT-II DR	0.48	0.30	2.56	0.11	1.62	0.90	2.93
	WMT	4.54	4.22	1.16	0.28	94.08	0.02	369181
	Change in SCS	-0.84	0.69	1.50	0.22	0.43	0.11	1.66
	WMT*PCL	2.26	1.64	1.88	0.17	9.54	0.38	238
	WMT* CVLT-II	-0.36	0.31	1.32	0.25	0.70	0.38	1.29

Table 11. Multinomial Logistic Regression Results for Hypothesis 3 without Service Connection Status

							95% Confidence Interval for Exp(B)	
		B	Std. Error	Wald	Sig.	Exp(B)	Lower Bound	Upper Bound
Unemployed vs. Part-time employment	Intercept	5.39	3.02	3.19	0.07			
	Age	0.05	0.04	1.64	0.20	1.05	0.98	1.13
	Education	-0.32	0.17	3.35	0.07	0.73	0.52	1.02
	Time since deployment	0.00	0.00	0.46	0.50	1.00	1.00	1.00
	LOC	-0.73	0.50	2.14	0.14	0.48	0.18	1.28
	PCL	0.62	0.83	0.56	0.45	1.86	0.36	9.53
	CVLT-II DR	-0.19	0.16	1.37	0.24	0.83	0.60	1.14
	WMT	-2.91	2.24	1.69	0.19	0.05	0.00	4.40
	WMT*PCL	-0.29	1.23	0.06	0.81	0.75	0.07	8.34
	WMT* CVLT-II	0.18	0.18	1.00	0.32	1.20	0.84	1.72
Unemployed vs. Full-time employment	Intercept	-5.05	4.47	1.28	0.26			
	Age	0.06	0.05	1.18	0.28	1.06	0.96	1.17
	Education	-0.10	0.22	0.23	0.63	0.90	0.59	1.38
	Time since deployment	0.00	0.00	0.17	0.68	1.00	1.00	1.00
	LOC	-1.01	0.65	2.40	0.12	0.36	0.10	1.31
	PCL	-2.77	1.33	4.35	0.04	0.06	0.00	0.85
	CVLT-II DR	0.45	0.28	2.53	0.11	1.56	0.90	2.71
	WMT	4.02	3.95	1.03	0.31	55.63	0.02	128681
	WMT*PCL	2.23	1.62	1.91	0.17	9.32	0.39	221.39
	WMT* CVLT-II	-0.34	0.29	1.31	0.25	0.71	0.40	1.27

Figure 1. Interaction between CVLT-II delayed recall score and WMT performance on MPAI Participation Index total score.



Appendix A

Defining mild TBI

Historically, the Glasgow Coma Scale (GCS) is one of the main measures for defining TBI severity; however, it was designed to track depth of coma following more severe TBI and is not sensitive to many of the common symptoms of mild TBI. Therefore, a variety of other measures are used in the diagnosis and classification of mild TBI. The American Congress of Rehabilitation Medicine (ACRM) defines mild TBI as a physiological disruption of brain function induced by a trauma resulting in a GCS of 13-15 within 30 minutes after the injury, and any period of LOC lasting 30 minutes or less, any loss of memory for the events (i.e., post traumatic amnesia (PTA)) immediately prior to the event or no more than 24 hours after the event, any alteration in mental status immediately following the incident, or any focal neurological deficits (ACRM, 1993). The Center for Disease Control (2003) and World Health Organization (Cassidy et al., 2004) have proposed similar definitions. In contrast, the Defense and Veterans Brain Injury Center (2006) is more broad in that it does not mention the criteria of LOC or posttraumatic amnesia, and defines mild TBI as any injury to the brain causing an alteration in mental status, typically resulting in any of the following symptoms: headache, nausea, vomiting, fatigue, dizziness, balance problems, sleep disturbances, drowsiness, sensitivity to light or noise, blurry vision, memory difficulties, or concentration difficulties. Though these definitions differ from each other slightly, they all essentially allow for a diagnosis of mild TBI to be formulated based solely on subjective report of injury characteristics and symptom complaints. Many of these subjective complaints are not specific to mild TBI, but occur at a high rate in the normal

population (Gouvier et al., 1988; Wang et al., 2006), which makes the issue of mild TBI diagnosis problematic. One highlight of the sports concussion literature, and the Sports as a Laboratory Assessment Model (Barth, Freeman, Broshek, & Varney, 2001), is that it allows for diagnosis of mild TBI at the time of injury, based on report of a trained professional, rather than historical self report of the patient with a history of mild TBI (McCrea, 2008).

In the sports literature, mild TBI is typically referred to as concussion. The American Academy of Neurology (1997) uses a grading scale defining three types of concussion. Grade 1 is when the patient experiences transient confusion, alteration of mental status or other concussion symptoms (e.g., headache, dizziness, nausea/vomiting, light-headedness, poor memory or attention, fatigue, irritability, sensitivity to light or noise, anxiety or depressed mood, sleep disturbance, ringing in ears) which resolve within 15 minutes, and no LOC. Grade 2 is when the patient experiences transient confusion, alteration of mental status or concussion symptoms lasting more than 15 minutes, and no LOC. Grade 3 is when the patient experiences any LOC. While this scale makes an attempt to differentiate mild TBI severity, it is not clear that it is able to discriminate between various outcomes; therefore, it should not be used for outcome prediction, but rather simply injury description.

While alteration of mental status is commonly used to diagnose mild TBI, it is not necessarily specific to mild TBI, and in fact, may be confused with psychological symptoms, such as when an unexpected exposure to a blast causes adrenaline, anxiety, fear, and/or change in awareness of one's environment (Brenner et al., 2009). The

nonspecific nature of alteration of mental status could lead to an over-diagnosis of mild TBI. Alternatively, oftentimes symptoms of mild TBI can go unnoticed, leading to under-diagnosis of mild TBI (McCrea, 2008). The latter issue may be especially salient in the case of combat related mild TBI, which frequently occurs in the context of otherwise life threatening situations.

Appendix B

PCL, HIT-6, ASSIST, and MPAI Participation Index forms

PTSD CheckList – Civilian Version (PCL-C)

Patient's Name: _____

Instructions: Below is a list of problems and complaints that veterans sometimes have in response to stressful life experiences. Please read each one carefully, put an "X" in the box to indicate how much you have been bothered by that problem *in the last month*.

	Response:	Not at all (1)	A little bit (2)	Moderately (3)	Quite a bit (4)	Extremely (5)
1.	Repeated, disturbing *memories*, *thoughts*, or *images* of a stressful experience from the past?					
2.	Repeated, disturbing *dreams* of a stressful experience from the past?					
3.	Suddenly *acting* or *feeling* as if a stressful experience *were happening again* (as if you were reliving it)?					
4.	Feeling *very upset* when *something reminded* you of a stressful experience from the past?					
5.	Having *physical reactions* (e.g., heart pounding, trouble breathing, or sweating) when *something reminded* you of a stressful experience from the past?					
6.	Avoid *thinking about* or *talking about* a stressful experience from the past or avoid *having feelings* related to it?					
7.	Avoid *activities* or *situations* because *they remind you* of a stressful experience from the past?					
8.	Trouble *remembering important parts* of a stressful experience from the past?					
9.	Loss of *interest in things that you used to enjoy*?					
10.	Feeling *distant* or *cut off* from other people?					
11.	Feeling *emotionally numb* or being unable to have loving feelings for those close to you?					
12.	Feeling as if your *future* will somehow be *cut short*?					
13.	Trouble *falling* or *staying asleep*?					
14.	Feeling *irritable* or having *angry outbursts*?					
15.	Having *difficulty concentrating*?					
16.	Being "*super alert*" or watchful on guard?					
17.	Feeling *jumpy* or easily startled?					

PCL-M for DSM-IV (11/1/94) Weathers, Litz, Huska, & Keane National Center for PTSD - Behavioral Science Division

HIT-6™

(Version 1.1)

This questionnaire was designed to help you describe and communicate the way you feel and what you cannot do because of headaches.

To complete, please circle one answer for each question.

HEADACHE IMPACT TEST™

1 When you have headaches, how often is the pain severe?

Never | Rarely | Sometimes | Very Often | Always

2 How often do headaches limit your ability to do usual daily activities including household work, work, school, or social activities?

Never | Rarely | Sometimes | Very Often | Always

3 When you have a headache, how often do you wish you could lie down?

Never | Rarely | Sometimes | Very Often | Always

4 In the past 4 weeks, how often have you felt too tired to do work or daily activities because of your headaches?

Never | Rarely | Sometimes | Very Often | Always

5 In the past 4 weeks, how often have you felt fed up or irritated because of your headaches?

Never | Rarely | Sometimes | Very Often | Always

6 In the past 4 weeks, how often did headaches limit your ability to concentrate on work or daily activities?

Never | Rarely | Sometimes | Very Often | Always

COLUMN 1 (6 points each)	+	COLUMN 2 (8 points each)	+	COLUMN 3 (10 points each)	+	COLUMN 4 (11 points each)	+	COLUMN 5 (13 points each)
▽		▽		▽		▽		▽

To score, add points for answers in each column.

Please share your HIT-6 results with your doctor.

Total Score ____

Higher scores indicate greater impact on your life.

Score range is 36-78.

A. WHO - ASSIST V3.0

INTERVIEWER ID		COUNTRY		CLINIC	
PATIENT ID		DATE			

INTRODUCTION ***(Please read to patient)***

Thank you for agreeing to take part in this brief interview about alcohol, tobacco products and other drugs. I am going to ask you some questions about your experience of using these substances across your lifetime and in the past three months. These substances can be smoked, swallowed, snorted, inhaled, injected or taken in the form of pills (show drug card).

Some of the substances listed may be prescribed by a doctor (like amphetamines, sedatives, pain medications). For this interview, we will not record medications that are used as prescribed by your doctor. However, if you have taken such medications for reasons other than prescription, or taken them more frequently or at higher doses than prescribed, please let me know. While we are also interested in knowing about your use of various illicit drugs, please be assured that information on such use will be treated as strictly confidential.

NOTE: BEFORE ASKING QUESTIONS, GIVE ASSIST RESPONSE CARD TO PATIENT

Question 1
(if completing follow-up please cross check the patient's answers with the answers given for Q1 at baseline. Any differences on this question should be queried)

In your life, which of the following substances have you ever used? *(NON-MEDICAL USE ONLY)*	No	Yes
a. Tobacco products (cigarettes, chewing tobacco, cigars, etc.)	0	3
b. Alcoholic beverages (beer, wine, spirits, etc.)	0	3
c. Cannabis (marijuana, pot, grass, hash, etc.)	0	3
d. Cocaine (coke, crack, etc.)	0	3
e. Amphetamine type stimulants (speed, diet pills, ecstasy, etc.)	0	3
f. Inhalants (nitrous, glue, petrol, paint thinner, etc.)	0	3
g. Sedatives or Sleeping Pills (Valium, Serepax, Rohypnol, etc.)	0	3
h. Hallucinogens (LSD, acid, mushrooms, PCP, Special K, etc.)	0	3
i. Opioids (heroin, morphine, methadone, codeine, etc.)	0	3
j. Other - specify:	0	3

Probe if all answers are negative:
"Not even when you were in school?"

If "No" to all items, stop interview.

If "Yes" to any of these items, ask Question 2 for each substance ever used.

Question 2

In the past three months, how often have you used the substances you mentioned *(FIRST DRUG, SECOND DRUG, ETC)*?	Never	Once or Twice	Monthly	Weekly	Daily or Almost Daily
a. Tobacco products (cigarettes, chewing tobacco, cigars, etc.)	0	2	3	4	6
b. Alcoholic beverages (beer, wine, spirits, etc.)	0	2	3	4	6
c. Cannabis (marijuana, pot, grass, hash, etc.)	0	2	3	4	6
d. Cocaine (coke, crack, etc.)	0	2	3	4	6
e. Amphetamine type stimulants (speed, diet pills, ecstasy, etc.)	0	2	3	4	6
f. Inhalants (nitrous, glue, petrol, paint thinner, etc.)	0	2	3	4	6
g. Sedatives or Sleeping Pills (Valium, Serepax, Rohypnol, etc.)	0	2	3	4	6
h. Hallucinogens (LSD, acid, mushrooms, PCP, Special K, etc.)	0	2	3	4	6
i. Opioids (heroin, morphine, methadone, codeine, etc.)	0	2	3	4	6
j. Other - specify:	0	2	3	4	6

If "Never" to all items in Question 2, skip to Question 6.

If any substances in Question 2 were used in the previous three months, continue with Questions 3, 4 & 5 for each substance used.

Question 3

During the past three months, how often have you had a strong desire or urge to use *(FIRST DRUG, SECOND DRUG, ETC)*?	Never	Once or Twice	Monthly	Weekly	Daily or Almost Daily
a. Tobacco products (cigarettes, chewing tobacco, cigars, etc.)	0	3	4	5	6
b. Alcoholic beverages (beer, wine, spirits, etc.)	0	3	4	5	6
c. Cannabis (marijuana, pot, grass, hash, etc.)	0	3	4	5	6
d. Cocaine (coke, crack, etc.)	0	3	4	5	6
e. Amphetamine type stimulants (speed, diet pills, ecstasy, etc.)	0	3	4	5	6
f. Inhalants (nitrous, glue, petrol, paint thinner, etc.)	0	3	4	5	6
g. Sedatives or Sleeping Pills (Valium, Serepax, Rohypnol, etc.)	0	3	4	5	6
h. Hallucinogens (LSD, acid, mushrooms, PCP, Special K, etc.)	0	3	4	5	6
i. Opioids (heroin, morphine, methadone, codeine, etc.)	0	3	4	5	6
j. Other - specify:	0	3	4	5	6

Question 4

During the past three months, how often has your use of *(FIRST DRUG, SECOND DRUG, ETC)* led to health, social, legal or financial problems?	Never	Once or Twice	Monthly	Weekly	Daily or Almost Daily
a. Tobacco products (cigarettes, chewing tobacco, cigars, etc.)	0	4	5	6	7
b. Alcoholic beverages (beer, wine, spirits, etc.)	0	4	5	6	7
c. Cannabis (marijuana, pot, grass, hash, etc.)	0	4	5	6	7
d. Cocaine (coke, crack, etc.)	0	4	5	6	7
e. Amphetamine type stimulants (speed, diet pills, ecstasy, etc.)	0	4	5	6	7
f. Inhalants (nitrous, glue, petrol, paint thinner, etc.)	0	4	5	6	7
g. Sedatives or Sleeping Pills (Valium, Serepax, Rohypnol, etc.)	0	4	5	6	7
h. Hallucinogens (LSD, acid, mushrooms, PCP, Special K, etc.)	0	4	5	6	7
i. Opioids (heroin, morphine, methadone, codeine, etc.)	0	4	5	6	7
j. Other - specify:	0	4	5	6	7

Question 5

During the past three months, how often have you failed to do what was normally expected of you because of your use of *(FIRST DRUG, SECOND DRUG, ETC)*?	Never	Once or Twice	Monthly	Weekly	Daily or Almost Daily
a. Tobacco products					
b. Alcoholic beverages (beer, wine, spirits, etc.)	0	5	6	7	8
c. Cannabis (marijuana, pot, grass, hash, etc.)	0	5	6	7	8
d. Cocaine (coke, crack, etc.)	0	5	6	7	8
e. Amphetamine type stimulants (speed, diet pills, ecstasy, etc.)	0	5	6	7	8
f. Inhalants (nitrous, glue, petrol, paint thinner, etc.)	0	5	6	7	8
g. Sedatives or Sleeping Pills (Valium, Serepax, Rohypnol, etc.)	0	5	6	7	8
h. Hallucinogens (LSD, acid, mushrooms, PCP, Special K, etc.)	0	5	6	7	8
i. Opioids (heroin, morphine, methadone, codeine, etc.)	0	5	6	7	8
j. Other - specify:	0	5	6	7	8

Ask Questions 6 & 7 for all substances ever used (i.e. those endorsed in Question 1)

Question 6

Has a friend or relative or anyone else ever expressed concern about your use of *(FIRST DRUG, SECOND DRUG, ETC.)?*	**No, Never**	**Yes, in the past 3 months**	**Yes, but not in the past 3 months**
a. Tobacco products (cigarettes, chewing tobacco, cigars, etc.)	0	6	3
b. Alcoholic beverages (beer, wine, spirits, etc.)	0	6	3
c. Cannabis (marijuana, pot, grass, hash, etc.)	0	6	3
d. Cocaine (coke, crack, etc.)	0	6	3
e. Amphetamine type stimulants (speed, diet pills, ecstasy, etc.)	0	6	3
f. Inhalants (nitrous, glue, petrol, paint thinner, etc.)	0	6	3
g. Sedatives or Sleeping Pills (Valium, Serepax, Rohypnol, etc.)	0	6	3
h. Hallucinogens (LSD, acid, mushrooms, PCP, Special K, etc.)	0	6	3
i. Opioids (heroin, morphine, methadone, codeine, etc.)	0	6	3
j. Other – specify:	0	6	3

Question 7

Have you ever tried and failed to control, cut down or stop using *(FIRST DRUG, SECOND DRUG, ETC.)?*	**No, Never**	**Yes, in the past 3 months**	**Yes, but not in the past 3 months**
a. Tobacco products (cigarettes, chewing tobacco, cigars, etc.)	0	6	3
b. Alcoholic beverages (beer, wine, spirits, etc.)	0	6	3
c. Cannabis (marijuana, pot, grass, hash, etc.)	0	6	3
d. Cocaine (coke, crack, etc.)	0	6	3
e. Amphetamine type stimulants (speed, diet pills, ecstasy, etc.)	0	6	3
f. Inhalants (nitrous, glue, petrol, paint thinner, etc.)	0	6	3
g. Sedatives or Sleeping Pills (Valium, Serepax, Rohypnol, etc.)	0	6	3
h. Hallucinogens (LSD, acid, mushrooms, PCP, Special K, etc.)	0	6	3
i. Opioids (heroin, morphine, methadone, codeine, etc.)	0	6	3
j. Other – specify:	0	6	3

Question 8

	No, Never	Yes, in the past 3 months	Yes, but not in the past 3 months
Have you ever used any drug by injection? *(NON-MEDICAL USE ONLY)*	0	2	1

IMPORTANT NOTE:

Patients who have injected drugs in the last 3 months should be asked about their pattern of injecting during this period, to determine their risk levels and the best course of intervention.

Pattern of Injecting		Intervention Guidelines
Once weekly or less Fewer than 3 days in a row	or	→ Brief Intervention including "risks associated with injecting" card
More than once per week 3 or more days in a row	or	→ Further assessment and more intensive treatment*

How to calculate a specific substance involvement score.

For each substance (labelled a. to j.) add up the scores received for questions 2 through 7 inclusive. Do not include the results from either Q1 or Q8 in this score. For example, a score for cannabis would be calculated as: **Q2c + Q3c + Q4c + Q5c + Q6c + Q7c**

Note that Q5 for tobacco is not coded, and is calculated as: **Q2a + Q3a + Q4a + Q6a + Q7a**

The type of intervention is determined by the patient's specific substance involvement score

	Record specific substance score	no intervention	receive brief intervention	more intensive treatment *
a. tobacco		0 - 3	4 - 26	27+
b. alcohol		0 - 10	11 - 26	27+
c. cannabis		0 - 3	4 - 26	27+
d. cocaine		0 - 3	4 - 26	27+
e. amphetamine		0 - 3	4 - 26	27+
f. inhalants		0 - 3	4 - 26	27+
g. sedatives		0 - 3	4 - 26	27+
h. hallucinogens		0 - 3	4 - 26	27+
i. opioids		0 - 3	4 - 26	27+
j. other drugs		0 - 3	4 - 26	27+

NOTE: *Further assessment and more intensive treatment may be provided by the health professional(s) within your primary care setting, or, by a specialist drug and alcohol treatment service when available.

Mayo-Portland Adaptability Inventory-4

Participation Index (M2PI)

Muriel D. Lezak, PhD, ABPP & James F. Malec, PhD, ABPP

Name: _____ Clinic # _____ Date _____

Person reporting (circle one): Single Professional Professional Consensus Person with brain injury Significant other: _____

Below each item, circle the number that best describes the level at which the person being evaluated experiences problems. Mark the greatest level of problem that is appropriate. Problems that interfere rarely with daily or valued activities, that is, less than 5% of the time, should be considered not to interfere. Write comments about specific items at the end of the rating scale.

1. Initiation: Problems getting started on activities without prompting				
0 None	**1** Mild problem but does not interfere with activities; may use assistive device or medication	**2** Mild problem; interferes with activities 5-24% of the time	**3** Moderate problem; interferes with activities 25-75% of the time	**4** Severe problem; interferes with activities more than 75% of the time
2. Social contact with friends, work associates, and other people who are not family, significant others, or professionals				
0 Normal involvement with others	**1** Mild difficulty in social situations but maintains normal involvement with others	**2** Mildly limited involvement with others (75-95% of normal interaction for age)	**3** Moderately limited involvement with others (25-74% of normal interaction for age)	**4** No or rare involvement with others (less than 25% of normal interaction for age)
3. Leisure and recreational activities				
0 Normal participation in leisure activities for age	**1** Mild difficulty in these activities but maintains normal participation	**2** Mildly limited participation (75-95% of normal participation for age)	**3** Moderately limited participation (25-74% of normal participation for age)	**4** No or rare participation (less than 25% of normal participation for age)
4. **Self-care:** Eating, dressing, bathing, hygiene				
0 Independent completion of self-care activities	**1** Mild difficulty, occasional omissions or mildly slowed completion of self-care; may use assistive device or require occasional prompting	**2** Requires a little assistance or supervision from others (5-24% of the time) including frequent prompting	**3** Requires moderate assistance or supervision from others (25-75% of the time)	**4** Requires extensive assistance or supervision from others (more than 75% of the time)
5. Residence: Responsibilities of independent living and homemaking(such as meal preparation, home repairs and maintenance, personal health maintenance beyond basic hygiene including medical management) but not including managing money (see # 8)				
0 Independent; living without supervision or concern from others	**1** Living without supervision but others have concerns about safety or managing responsibilities	**2** Requires a little assistance or supervision from others (5-24% of the time)	**3** Requires moderate assistance or supervision from others (25-75% of the time)	**4** Requires extensive assistance or supervision from others (more than 75% of the time)
6. *Transportation				
0 Independent in all modes of transportation including independent ability to operate a personal motor vehicle	**1** Independent in all modes of transportation, but others have concerns about safety	**2** Requires a little assistance or supervision from others (5-24% of the time); cannot drive	**3** Requires moderate assistance or supervision from others (25-75% of the time); cannot drive	**4** Requires extensive assistance or supervision from others (more than 75% of the time); cannot drive

DC 1YR 2YR

7A. *Paid Employment: Rate either item 7A or 7B to reflect the primary desired social role. Do not rate both. Rate 7A if the primary social role is paid employment. If another social role is primary, rate only 7B. For both 7A and 7B, "support" means special help from another person with responsibilities (such as, a job coach or shadow, tutor, helper) or reduced responsibilities. Modifications to the physical environment that facilitate employment are not considered as support.									
0	Full-time (more than 30 hrs/wk) without support	1	Part-time (3 to 30 hrs/ wk) without support	2	Full-time or part-time with support	3	Sheltered work	4	Unemployed; employed less than 3 hours per week
7B. *Other employment: Involved in constructive, role-appropriate activity other than paid employment. Check only one to indicate primary desired social role: Childrearing/care-giving Homemaker, no childrearing or care-giving Student Volunteer Retired (Check retired only if over age 60; if unemployed, retired as disabled and under age 60, indicate "Unemployed" for item 7A.									
0	Full-time (more than 30 hrs/wk) without support; full-time course load for students	1	Part-time (3 to 30 hrs/ wk) without support	2	Full-time or part-time with support	3	Activities in a supervised environment other than a sheltered workshop	4	Inactive; involved in role-appropriate activities less than 3 hours per week
8. Managing money and finances: Shopping, keeping a check book or other bank account, managing personal income and investments									
0	Independent, manages money without supervision or concern from others	1	Manages money independently but others have concerns	2	Requires mild assistance or supervision from others (5-24% of the time)	3	Requires moderate assistance or supervision from others (25-75% of the time)	4	Requires extensive assistance or supervision from others (more than 75% of the time)

Comments:

Item #

_____ _____

_____ _____

_____ _____

Items with an asterisk (6, 7A or 7B) require rescoring as specified below before raw scores are summed and referred to reference tables to obtain standard T-scores.

Rescore item 6. Original score = _____
If original score = 0 or 1, new score = 0
If original score = 2 or 3, new score = 1
If original score = 4, new score = 3

Rescore item 7A or 7B. Original score = _____
If original score = 0, new score = 0
If original score = 1 or 2, new score = 1
If original score = 3 or 4, new score = 3

New score for item 6 = _____
New score for item 7Aor 7B = _____
Sum of scores for other items (1-5 & 8) _____
TOTAL = _____ Standard T-score = _____