Journal of the International Neuropsychological Society (2012), **18**, 390–393.

doi:10.1017/S1355617712000367

VIRTUAL ISSUE—INTRODUCTION

Mild Traumatic Brain Injury and Posttraumatic Stress Disorder: Clinical and Conceptual Complexities

Jennifer J. Vasterling,[1] AND Sureyya Dikmen[2]

[1]VA Boston Healthcare System and Boston University School of Medicine, Boston, Massachusetts
[2]Department of Rehabilitation Medicine, University of Washington, Seattle, Washington

INTRODUCTION

The wars in Iraq and Afghanistan have raised public consciousness of traumatic brain injury (TBI) and posttraumatic stress disorder (PTSD), two of the most common health consequences of contemporary military deployment. TBI and PTSD may each in their own right exert a toll on affected individuals. Within the war zone, however, brain injury often occurs within a broader context of extreme psychological stress (i.e., traumatic stress). The same dangerous circumstances (e.g., combat, encounters with improvised explosive devices) that lead to increased risk of TBI also place service members at increased risk for PTSD. Therefore, the prevalence of PTSD in returning war-zone veterans who have a history of deployment-related TBI are elevated, especially when the brain injury falls at the milder end of the severity range, as is the case with the majority of deployment-related TBIs. For example, a RAND study estimated that almost 20% of a representative sample of Operation Enduring Freedom/Operation Iraqi Freedom veterans screened positive for history of mild TBI (mTBI), and that of those reporting a deployment mTBI, approximately 34% also screened positive for PTSD (Tanielian & Jaycox, 2008).

The comorbidity of mTBI and PTSD is not limited, however, to war-zone veterans. Civilian events such as motor vehicle accidents and interpersonal assault may also be associated with both TBI and psychological trauma sufficiently severe to lead to PTSD. The prevalence of comorbid mTBI and PTSD is not well-documented in civilians, but mTBI and/or PTSD each affect many civilians. The Centers for Disease Control and Prevention (2010) estimate that over 1.7 million people sustain a TBI each year, and that over 75% of these injuries are mild. A U.S. population-based survey estimated the prevalence of PTSD in the general population to be at 7–8% (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995).

Despite the relatively high rates of mTBI and PTSD in at-risk populations, much remains unknown about the clinical consequences in individuals who have both incurred an mTBI and experience PTSD. The sequelae of mTBI are often referred to as post traumatic or post concussive symptoms. Some post traumatic symptoms (e.g., irritability, neurocognitive complaints) overlap with PTSD symptoms, making differential diagnosis difficult. Other conditions commonly co-occurring with TBI history and PTSD, such as chronic pain, depression, and substance abuse, may further complicate the clinical presentation of patients with both history of mTBI and PTSD. As a result, considerable challenges arise in regards to both the assessment and clinical management of patients with co-morbid mTBI and PTSD.

The field of neuropsychology is well-positioned to tackle many of the clinical and conceptual challenges posed by comorbid mTBI and PTSD. This virtual special issue of the *Journal of the International Neuropsychological Society (JINS)* compiles eight papers on the topic of TBI and/or PTSD that were previously published in regular issues of *JINS*. The papers are for the first time grouped together with the goal of collectively addressing the issues confronting clinicians who assess and care for patients with history of mTBI and PTSD.

BIOPSYCHOSOCIAL ASPECTS OF RECOVERY FROM MILD TBI AND PSYCHOLOGICAL TRAUMA

Although TBI is precipitated by a physical event (i.e., external force to the brain) and PTSD is precipitated by a psychological event (i.e., psychological trauma), a growing body of evidence suggests that biological and psychosocial factors are relevant to both mTBI recovery and PTSD course. Although initiated by neurophysiological mechanisms, recovery from mTBI appears to be influenced by psychosocial and contextual factors in addition to injury characteristics and other biological

Correspondence and reprint requests to: Jennifer J. Vasterling, Psychology Service and VA National Center for PTSD, VA Boston Healthcare System, (116B), 150 S. Huntington Avenue, Boston, MA 02130. E-mail: jennifer.vasterling@va.gov, and to Dr. Sureyya Dikmen, Department of Rehabilitation Medicine, Mail Stop: 359612, Harborview Medical Center, 325 Ninth Avenue, Seattle, Washington 98104. E-mail: Dikmen@u.washington.edu

mechanisms. Likewise, although characterized by observable emotional and behavioral symptoms, PTSD is accompanied by biological, neural, and neuropsychological abnormalities, some of which may influence the development and course of emotional symptoms following trauma exposure. This issue begins with papers that provide a better understanding of the range of factors that likely influence recovery from mTBI, next turns to papers that illustrate the neuropsychological features of PTSD, and concludes with papers that consider the co-morbidity of mTBI with PTSD.

mTBI

Although many individuals recover following mTBI, the cognitive, behavioral, and emotional sequelae of mTBI endure in a subset of patients. Included as the first paper in the virtual issue, Bigler (2008) presents a review of the neuropsychology and clinical neuroscience of persistent post-concussive symptoms, discussing diagnostic considerations and emphasizing in particular current knowledge about neuropathological substrates potentially underlying persistent symptoms. As illustrated in this virtual issue by Dikmen, Machamer, Fann, and Temkin (2010), the subset of patients with history of TBI reporting post traumatic symptoms is sizable. Although fewer patients in their sample with mTBI, as compared to those with moderate to severe TBI, reported enduring post-concussive symptoms, 44% of patients with uncomplicated mTBI continued to report three or more symptoms as long as 1 year following their injury in contrast with 24% of the injury control group. Highlighting the complex constellation of factors that may interact to determine the longer-term outcome of TBI, Dikmen et al. (2010) identify a number of variables, including age, gender, preinjury alcohol abuse, pre-injury psychiatric history, and TBI severity, that each influence recovery.

There is recognition that subjective complaints and neuropsychological performances sometimes diverge. Complementing the Dikmen et al. (2010) study, which examined subjective complaints following TBI, we include in this issue a meta-analysis of studies examining performance-based neuropsychological outcomes (Belanger, Curtiss, Demery, Lebowitz, & Vanderploeg, 2005). In their meta-analysis, Belanger et al. (2005) found that within the first 3 months post-injury, as compared to control samples, mTBI history in unselected samples was associated with mild neuropsychological impairments, especially in the domains of fluency and delayed memory recall. However, these deficits were generally not maintained beyond three months. Only clinic-based samples and samples including participants in litigation showed lingering performance deficits after three months, highlighting the potential role of contextual factors in recovery.

PTSD

A growing literature has suggested that PTSD is associated with specific neurobiological, neural, and neuropsychological abnormalities. Such abnormalities are thought to be related to the behavioral and emotional expression of the disorder, and reflect current neuroanatomical and neuropsychological conceptualizations of PTSD (e.g., Rauch, Shin, & Phelps, 2006). Specifically, PTSD is thought to involve functional and structural abnormalities in fear circuitry, with the amgydala, hippocampus, and medial prefrontal cortex featuring prominently among involved structures. Woodward et al. (2009), included in this virtual issue, documented verbal declarative memory deficits in PTSD patients that could not be accounted for by history of alcohol use, age, or estimated premorbid intellectual functioning. Although PTSD patients in the sample by Woodward et al. also showed smaller hippocampal volumes relative to no-PTSD controls, memory performance and hippocampal volume were not linearly related, suggesting that other PTSD-related factors (e.g., increased central arousal, prefrontal dysfunction) may have contributed to memory deficits. Regardless of the source of memory impairment, the results of Woodward et al. (2009) highlight the need to take into account the potential neuropsychological and neurobiological features of psychiatric disorders, including PTSD, that may be comorbid to mTBI.

The majority of studies examining neuropsychological functioning and PTSD do not address whether neuropsychological impairment precedes PTSD, or instead is consequential to PTSD. Included in this issue, Marx, Doron-Lamarca, Proctor and Vasterling (2009) used prospective methodology to examine associations between pre-deployment neuropsychological performance and PTSD symptom change from pre- to post-deployment. Their findings indicate that visual memory decrements documented prior to war-zone deployment confer additional risk of post-deployment PTSD symptoms beyond the variance contributed by the intensity of individual combat experiences and pre-existing PTSD symptoms. Although there are likely many sources of cognitive variation among individuals who are trauma exposed, TBI may be one potential source of memory deficit. The findings of Marx et al. (2009) raise the possibility that, if TBI results in even mild memory impairment for some individuals, those individuals may have increased PTSD symptoms following psychological trauma exposure.

Co-morbid mTBI and PTSD

Although varying in their specific focus, the final three papers included in this virtual issue address mTBI and PTSD concurrently. Two of these papers center on deployment-related mTBI and examine the specific question of whether blast-related TBI—a particularly common source of deployment TBI—differs in its impact from non–blast-related deployment TBI. Although deployment-related blast injuries often involve other sources of neurological insult (e.g., projectile injuries, being thrown as a result of the blast), the physiological mechanisms associated with the primary blast injury, and whether they differ from non-blast-related injuries, remain uncertain. Luethcke, Bryan, Morrow, and Isler (2011), this issue, compared blast to non-blast injuries in deployed service members and civilian contractors, with documented mTBIs in

https://doi.org/10.1017/S1355617712000367 Published online by Cambridge University Press

the acute recovery phase (i.e., within 72 hr of their injury). Findings revealed few differences between blast and non-blast TBI in self-reported post-concussive symptoms, PTSD symptoms, or neuropsychological performances. However, within a smaller subset of participants for whom they were able to access archived pre-deployment neuropsychological test data, both blast- and non-blast injuries demonstrated decreases in reaction time efficiency providing evidence for early cognitive decline associated with mTBI, a finding similar to those with civilian injuries. Lippa, Pastorek, Benge, and Thornton (2010), this issue, found that report of post-concussive symptoms in veterans receiving care months after returning from deployment did not vary as a function of self reported injury mechanism (blast *vs.* non-blast) or its characteristics (e.g., distance from, number of exposures). However, posttraumatic stress symptoms, which were more pronounced in veterans with history of blast, were significantly correlated with self-reported post-concussive symptoms, highlighting the potential exacerbating effects of PTSD on mTBI recovery.

The final paper included in this virtual issue (Bryant et al., 2009) focuses on PTSD symptom outcomes as a function of mTBI and of the duration of posttraumatic amnesia in civilians admitted to Australian trauma centers and assessed for PTSD symptoms approximately one week after the injury and again three months later. Consistent with the deployment TBI literature, Bryant et al. (2009) found that compared to patients with non-brain-related injuries, those with mTBI were more likely to develop PTSD within three months following TBI, even after taking into account general injury severity. Of interest, among patients with mTBI, longer posttraumatic amnesia was associated with less severe intrusive memories of the event. These findings point both to the risk mTBI confers of subsequent PTSD development and, somewhat paradoxically, to the possibility that certain aspects of TBI (e.g., posttraumatic amnesia) may confer time-limited (seen within the first week post-injury but not three months later), protective effects against specific PTSD symptoms.

FUTURE DIRECTIONS

The issue of whether mTBI and/or PTSD are responsible for symptoms reported and for poor health is controversial. Future directions will depend on the focus of the questions being asked or deciding what is important to study. From a clinical point of view, clinicians are confronted with many challenges in the care of patients with co-morbid mTBI and PTSD. Diagnostic determinations are clouded by common symptoms, partial overlap in neural substrates, and complications from other co-morbid disorders such as chronic pain and substance abuse. As suggested by divergences in subjective and performance-based outcome measures, it will be important for both clinical care and research to incorporate multi-modal outcome measures (e.g., performance-based neuropsychological tests, subjective complaints, measures of day to day functioning, newer neuroimaging techniques, structured clinical interviews). Although not always possible, capture of observer reports and medical record documentation will serve as an important supplement to retrospective accounts of TBI events and their immediate sequelae.

Formulation of prognosis and treatment plans reflective of individual prognoses can also be challenging. As demonstrated by many of the papers in this issue, outcomes in patients with history of mTBI and PTSD depend on a complex constellation of factors, including but not limited to the recency of the injury event, the psychological context of the injury event, the severity of mTBI (as indexed by such factors as the duration of posttraumatic amnesia, and the depth and duration of loss of consciousness), the severity and duration of PTSD symptoms, the presence of other somatic and psychiatric comorbidities, the potential for secondary gain, and a host of other biological, psychological, and contextual risk and resilience factors. Research employing longitudinal designs will help identify risk and protective factors for clinical outcomes following mTBI and PTSD. In particular, assessment of pre-injury and pre-trauma variables in addition to assessment of acute and longer-term outcomes will help to both elucidate the natural course of symptoms, as well as those factors that modify risk for poor outcomes.

Clinical care would benefit from information on how PTSD and mTBI may interact, and whether their co-occurrence leads to poorer outcomes than would be consequent to either condition alone. Of particular potential value is further understanding of possible bi-directional relationships between mTBI and PTSD. This may be especially relevant in contexts such as war-zone deployment in which there may be one or more brain injury events that occur in the context of on-going or repetitive psychological trauma. Preliminary information, some derived from the studies included in this issue, suggest that mTBI and PTSD may each influence recovery from the other.

Likewise, it is plausible that mTBI and PTSD would influence treatment response to the interventions tailored to each intervention. For example, do psychiatric symptoms such as intrusive memories or feelings of being emotionally overwhelmed distract patients in the context of various rehabilitation techniques (e.g., especially those requiring focused attention)? As an example relevant to some PTSD interventions, a patient may have difficulty retrieving all aspects of their psychological trauma because of TBI-related encoding deficits experienced during or shortly after a trauma event involving brain injury. In such cases, it is unknown whether degraded ability to access the trauma memory would affect response to PTSD treatment interventions, such as prolonged exposure, that depend on the ability to create narrative accounts of the trauma and associated emotions. Inclusion of both neuropsychological and psychiatric measures pre- and post-interventions in treatment outcome studies will further understanding of whether and if the mTBI/PTSD comorbidity alters response to rehabilitation and PTSD interventions.

The potential mechanisms by which mTBI and PTSD influence recovery from each other and/or response to the interventions typically employed for each condition span biological, psychosocial, and neurocognitive factors, but this question warrants considerably more empirical data. Future work will also build on current knowledge by expanding the

https://doi.org/10.1017/S1355617712000367 Published online by Cambridge University Press

representativeness of the samples studied to allow for greater generalization of findings. Ultimately, better understanding of the mechanisms that are at play when mTBI and PTSD are comorbid will inform assessment practices, and where, when, and how treatments are best delivered. The body of work summarized in this issue helps identify some of the problems experienced by patients with comorbid mTBI and PTSD and sets the stage expanding the knowledge of this complex comorbidity.

REFERENCES

Belanger, H.G., Curtiss, G., Demery, J.A., Lebowitz, B.K., & Vanderploeg, R.D. (2005). Factors moderating neuropsychological outcomes following mild traumatic brain injury: A meta-analysis. *Journal of the International Neuropsychological Society*, *11*, 215–227.

Bigler, E.D. (2008). Neuropsychology and clinical neuroscience of persistent post-concussive syndrome. *Journal of the International Neuropsychological Society*, *14*, 1–22.

Bryant, R.A., Creamer, M., O'Donnell, M., Silove, D., Clark, C.R., & McFarlane, A.C. (2009). Posttraumatic amnesia and the nature of posttraumatic stress disorder after mild traumatic brain injury. *Journal of the International Neuropsychological Society*, *15*, 862–867.

Centers for Disease Control and Prevention. (2010). Injury prevention and control: Traumatic brain injury. Retrieved from http://www.cdc.gov/traumaticbraininjury/statistics.html

Dikmen, S., Machamer, J., Fann, J.R., & Temkin, N.R. (2010). Rates of symptom reporting following traumatic brain injury. *Journal of the International Neuropsychological Society*, *16*, 401–411.

Kessler, R.C., Sonnega, A., Bromet, E., Hughes, M., & Nelson, C.B. (1995). Posttraumatic stress disorder in the National Comorbidity Survey. *Archives of General Psychiatry*, *52*(12), 1048–1060.

Lippa, S.M., Pastorek, N.J., Benge, J.F., & Thornton, G.M. (2010). Postconcussive symptoms after blast and nonblast-related mild traumatic brain injuries in Afghanistan and Iraq War veterans. *Journal of the International Neuropsychological Society*, *16*, 856–866.

Luethcke, C.A., Bryan, C.J., Morrow, C.E., & Isler, W.C. (2011). Comparison of concussive symptoms, cognitive performance, and psychological symptoms between acute blast- versus nonblast-induced mild traumatic brain injury. *Journal of the International Neuropsychological Society*, *17*, 36–45.

Marx, B.P., Doron-Lamarca, S., Proctor, S.P., & Vasterling, J.J. (2009). The influence of pre-deployment neurocognitive functioning on post-deployment PTSD symptom outcomes among Iraq-deployed Army soldiers. *Journal of the International Neuropsychological Society*, *15*, 840–852.

Rauch, S.L., Shin, L.M., & Phelps, E.A. (2006). Neurocircuitry models of posttraumatic stress disorder and extinction: Human neuroimaging research – Past, present, and future. *Biological Psychiatry*, *60*, 376–382.

Tanielian, T., & Jaycox, L.H. (2008). *Invisible wounds of war: Psychological and cognitive injuries, their consequences, and services to assist recovery*. Santa Monica, CA: RAND Corporation.

Woodward, S.H., Kaloupek, D.G., Grande, L.J., Stegman, W.K., Kutter, C.J., Leskin, L., … Eliez, S. (2009). Hippocampal volume and declarative memory function in combat-related PTSD. *Journal of the International Neuropsychological Society*, *15*, 830–839 .

https://doi.org/10.1017/S1355617712000367 Published online by Cambridge University Press